THE EXPANDED METAL SYSTEM OF STEEL-CONCRETE CONSTRUCTION

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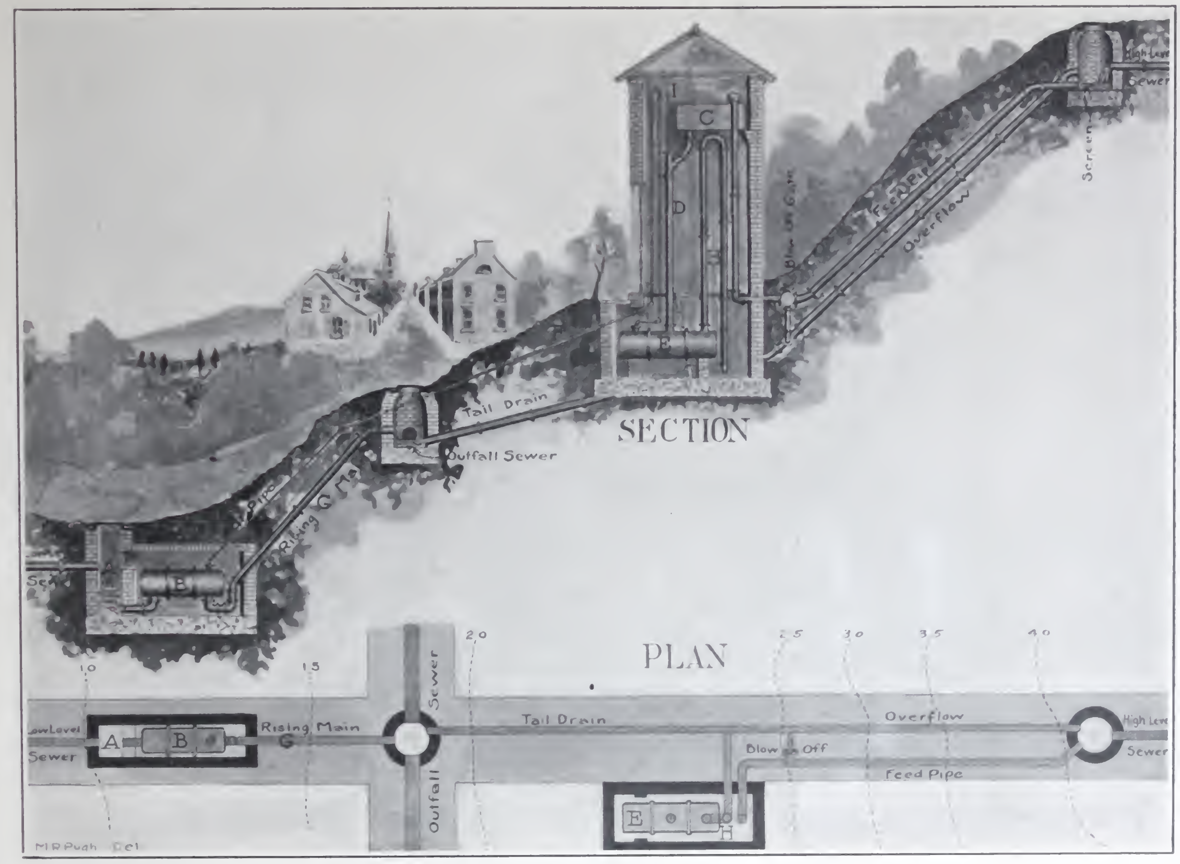

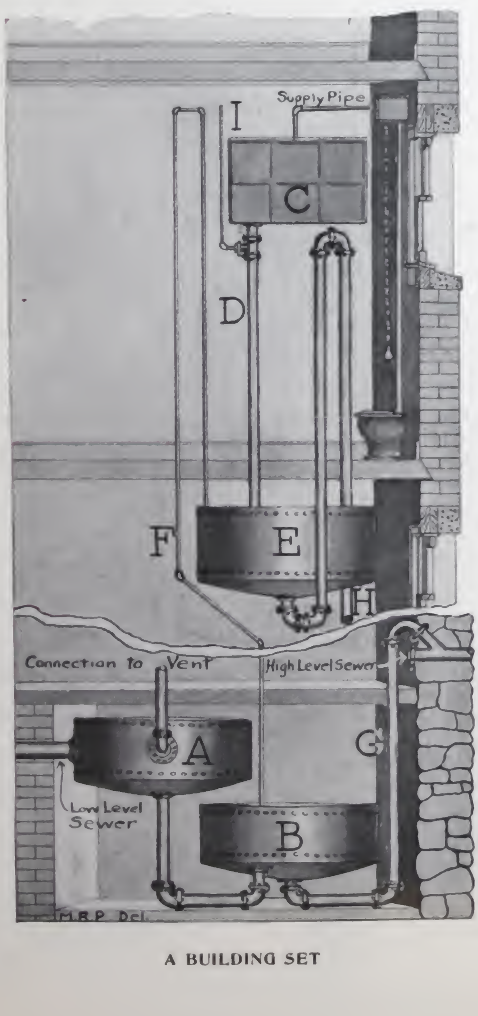

A BUILDING SET

WATER or sewage in high level system gravitates into flush tank C which, when the flushing point is reached, discharges its contents through pressure pipe D into air-cylinder E, forcing the air therein through air-pipe F. The sewage which has gravitated through the low level system into sewage receiver A, and thence (passing flap valve which prevents its return) into forcing cylinder B, is thus lifted into the high level sewer through rising main G.

The contents of flush tank C are sufficient to completely empty the air-cylinder of air, and also fill pipes D and H, thus bringing into action and automatically withdrawing the liquid contents of air-cylinder E and recharging same with air through vent pipe I in readiness for the next discharge. In building sets, the water thus withdrawn may be collected in a supplementary water tank and from thence feed the fixtures which are below it.

In cases where "wastes" are not available for pressure liquid, a small open dome is placed in sewage receiver A connected by air-pipe with flush tank C, which latter will then discharge only when forcing cylinder B is filled and the sewage rising in sewage receiver A displaces the air in the dome. Inasmuch as the pressure liquid is discharged into the high level system, it may be used for supplying sanitary fixtures (in office buildings), flushing sewers, etc.

The Automatic Sewage Lift

Superior to an engine and pump. Actuated by air, compressed by a falling column of liquid in transit to fixtures or sewers. Always ready for immediate use.

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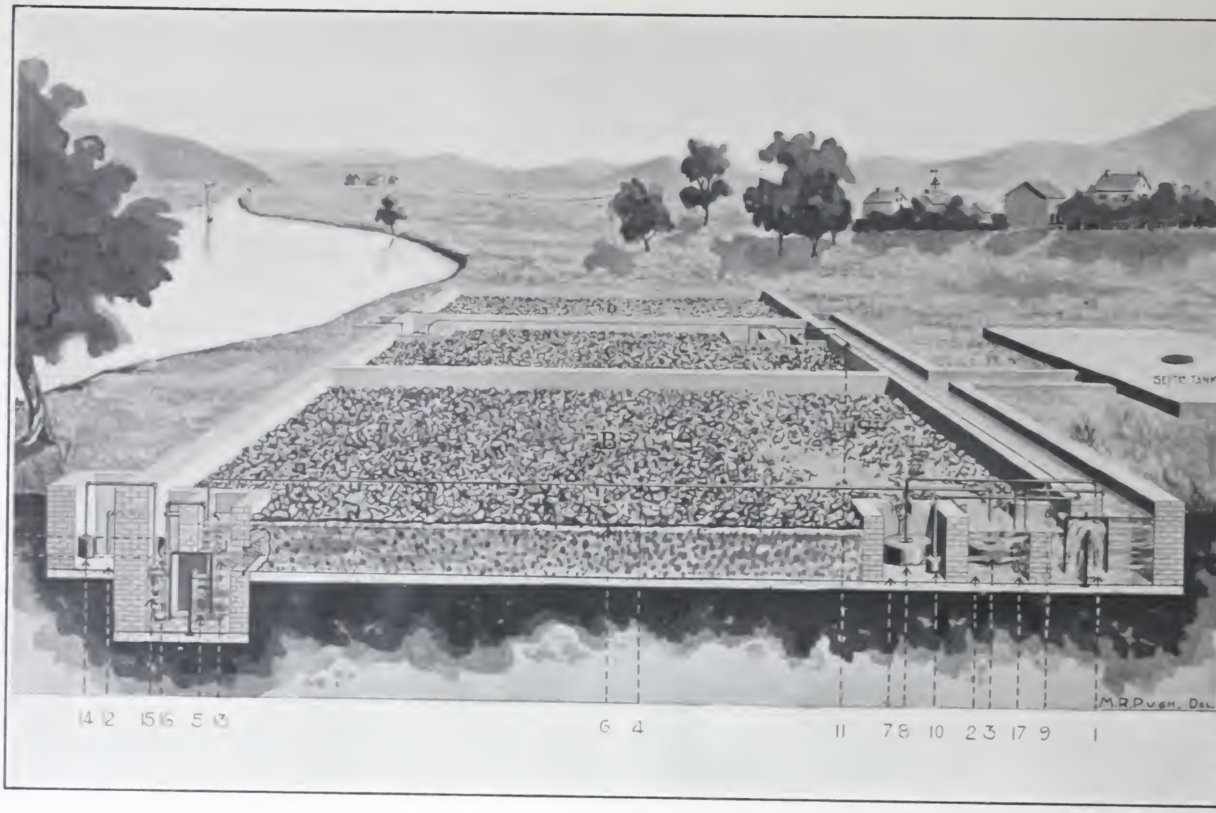

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- By the City of Charlotte, N. C.
- By the Town of Hanover, Pa.
- By the Village of Ridgewood, N. J.
- At the Works of the Lackawanna Steel Company, Buffalo, N. Y.
- At the Eastern Reformatory, Napanoch, N. Y.

Flow of Sewage from Septic Tank to Ridge and Furrow Filters at Eastern New York Reformatory, Napanoch, N. Y.

"Automatically operated by a simple arrangement of air bells and connecting pipes without moving parts, which permit the entire flow of sewage to pass through the first Chamber until the sewage in the open furrow reaches the depth of 18 inches, and then by causing an air bind in the feed pipe, automatically cuts off its own supply and transfers the entire flow to the second chamber and its open furrow. Here the process is repeated and again consecutively, in the third and fourth chambers, the last returning the flow to the first, and beginning the circle over."

(See Fifty-seventh Annual Report of the Prison Association of New York, page 37).

RIDGE AND FURROW FILTER AUTOMATICALLY CONTROLED

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No moving parts. May be operated without additional head.

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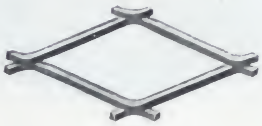
Form 61. 11-04-3M.

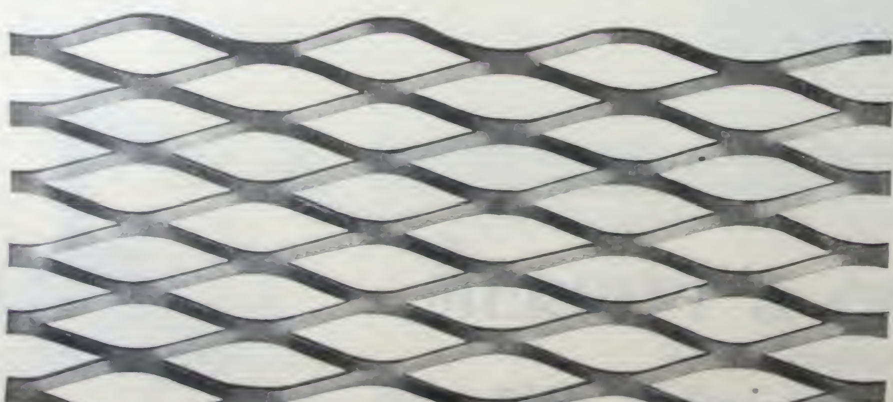
STANDARD SIZES C

3 in. Mesh, No. 10 Gauge Steel.
(Has sectional area .185 sq. ins.
per foot of width.)
Sheets 6 ft. x 8 ft.; 5 sheets per bundle
= 240 sq. ft.



½ inch Mesh,
No. 18 Gauge.
Sheets, 3 ft. x 8 ft.

6 in. Mesh,
(Has sectional ar
Sheets 5 ft. x 8
=



"Diamond" Lath.
24 Gauge. Sheets, 18 ins. x 96 ins. 20 sq. yds. per bundle.
26 Gauge. Sheets, 24 ins. x 96 ins. 16 sq. yds. per bundle.

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EXPANDED METAL.

2 in. Mesh, No.12 Gauge.
Sheets 5 ft. x 8 ft.; 5 sheets per bundle = 200 sq. ft.

¾ in. Mesh, No. 13 Gauge.
Sheets 6 ft. x 8 ft.; 5 sheets per bundle = 240 sq. ft.

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Sheets 4 ft. x 8 ft.; 5 sheets per bundle = 160 sq. ft.

uge Steel.
sq. ins. per foot

ts per bundle

"A" Lath.
24 Gauge. Sheets, 18 ins. x 96 ins. 12 sq. yds. per bundle.
"B" Lath.
27 Gauge. Sheets, 18 ins. x 96 ins. 20 sq. yds. per bundle.

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EXPANDED METAL

NOTWITHSTANDING Expanded Metal has been a staple in the commercial list of construction materials for the last fifteen years, it is nevertheless still regarded as a unique product in the mechanical world. Although originally designed and perfected with a view to a special use as a mesh for the manufacture of fences, guards and railings, in which field it still has a considerable demand, it is at this time a very large

Figure 1

factor in structural operations throughout the world. Curiously enough almost any mechanic upon examination of a sample of the metal to-day would say, "that's an easy thing to make," but for all that it required great skill and much patience to bring it to a point of commercial perfection. As a material it is nothing more or less than a plain sheet of steel, which, by an automatic machine, is opened into meshes of any desired size or section of

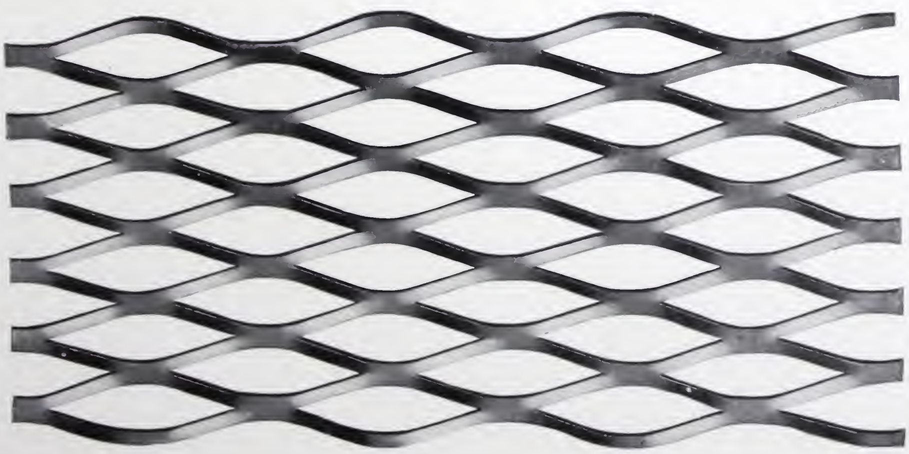


Figure 2

strand. The operation is accomplished, as said, by an automatic machine which receives the sheet cold, and at a single stroke the slitting and opening of the meshes are simultaneously accomplished. No material is wasted, no pieces are lost, and the elastic limit of the steel is increased. The finished sheet of Expanded Metal is from three to eight times as large as the original sheet of steel, according to the size of the meshes in the finished sheet.

The material is made to-day, for the most part, by machines which give a product in uniform length of 8 feet, the width being 12 inches to 72 inches, as occasion may require. Steel as light as 27 gauge is used with meshes only $\frac{3}{8}$ of an inch, while for other purposes sheets are being cut from No. 3 steel with diamond meshes 5 inches by 12 inches, with many intervening sizes and weights, making possible any desired combination of mesh size and strength.

In the accompanying illustrations are shown three standard types of material. The first, Fig. 1, represents the original form in which the material was commercially produced as a lathing mesh, and in this form it is still being made with perfect success mechanically and with entire satisfaction to users. There is no better material made upon which to plaster than this. Fig. 2 represents a more recent production in the way of a lathing mesh which is described as "diamond mesh." In common practice sheets of these two materials are produced in lengths of 8 feet and in widths of 18 inches, and they constitute the standard in the specifications of all leading architects throughout the country. Fig. 3 is the typical form of mesh which has been developed for uses quite too numerous to mention in this catalogue; suffice it to say that meshes including $\frac{3}{4}$ inch, $1\frac{1}{2}$ inches, 2 inches, 3 inches, 4 inches, and 6 inches are produced to-day and meeting large demands, according to their fitness for the particular case in hand. In the sheet accompanying this book are shown in full form what may be termed standard sizes. It

Figure 3

would be impossible to designate the special fitness for each material in a catalogue of this kind. The two lathing meshes and their variations in widths of sheets and in weight of steel are used according to the mechanical requirements. The other meshes answer the purpose for the manufacture of guards, railings, lockers, etc., for the smaller meshes, while the larger ones are used for concrete reinforcement, according to the engineer's design.

It may be said in this connection that no material of a structural character has ever been produced which has found so wide a field of practical adaptation, as intimated above. The invention was brought about with a view of making a mesh formation of steel to answer a demand for fences, railings and kindred work. At the time of its creation there was a vast commercial demand for metallic fencing, and barbed wire, then selling at $200 per ton, making a field for a new material. During the few years following the accomplishment of Expanded Metal mechanically, manufacturers had not thought of its use as a concrete reinforcement. This came about as an adaptation, or an after thought, in the development of a market. The multiplied uses to which the material has been put are only partly shown on the succeeding pages of this catalogue, and sufficient data we believe is herewith furnished to indicate wide possibilities in the use of a very valuable material.

Specific information can be had of any of the Associated Companies or of any of their agencies.

Reinforced Concrete Construction Theoretically Considered

As a building material concrete has gradually advanced in favor, by virtue of its durability, adaptability and the facility offered for rapid construction at a moderate cost. The resistance offered by plain concrete, however, to tensile and shearing stresses is so small and unreliable as to practically prohibit its use, with economy and safety, in structures subjected to the stresses mentioned, and this fact alone, until recently, has greatly retarded a more extensive use. The fortunate discovery that concrete may be reinforced with metal so as to largely increase the resistance to tensile and shearing stresses has entirely overcome the serious objection mentioned, greatly extending the scope of application, thus bringing reinforced concrete rapidly to the front rank of ideal materials for construction. Introducing the metal converts a practically inelastic body into one possessing elasticity in addition to durability, increasing strength with age, rust-proof and fire-resisting qualities, susceptibility to rapid and economical execution, pliability to various forms, and, finally, innumerable aesthetic possibilities The reader is referred to Fig. 4 as a valuable object lesson of the benefits resulting from the introduction of reinforcement. The sections shown represent a plain concrete beam and one reinforced with

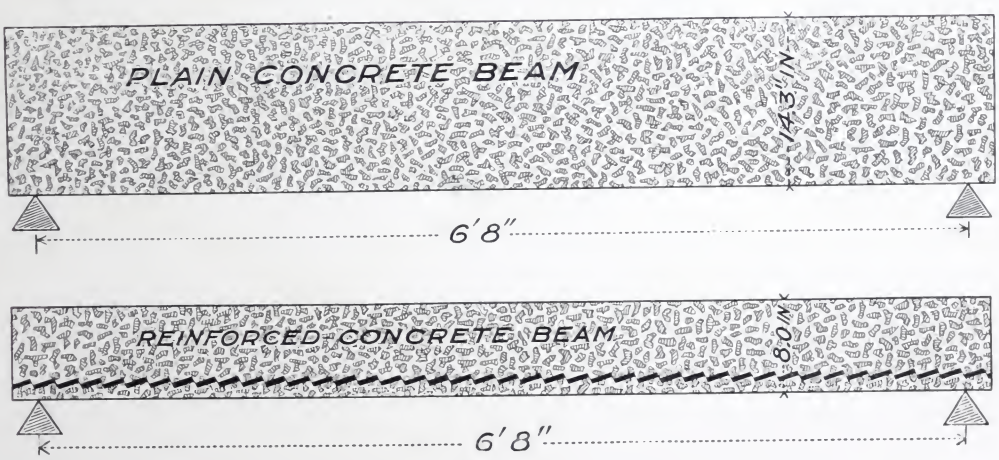


Figure 4

one per cent. of metal. They are designed in strict accord with data obtained by Prof. W. K. Hatt from full-sized, plain and reinforced beams tested to destruction. Each has the same width and is proportioned to develop equal resistance to a given load similarly applied to both. The diminution of depth obtained by inserting the reinforcement represents, therefore, an equal saving in weight and head-room, also a proportionate reduction in cost, extending to all members of the structure influenced by the weight of the beam under consideration. Moreover, the composite beam possesses an incalculable element of safety as compared with a plain concrete beam, in that ample warning is given before final rupture takes place. It is impractical to discuss at length the theory of reinforcing concrete. We trust, however, that the following brief enumeration of the general principles will suffice as a guide to a practical working knowledge of the subject for those who may not spare the time for a more thorough investigation.

The fundamental principle may be stated as follows: In any structural member, mortar or concrete, reinforced by metal, is capable of sustaining very much greater elongations than when not reinforced and still effectually contribute to the resistance of the member.

This premise is amply confirmed by numerous tests, the results differing only in the degree of elasticity imparted to the concrete by the reinforcing metal. M. Considère concludes, from the results of his exhaustive

researches, that the extensibility of concrete is increased at least ten-fold by reinforcement and accounts for the phenomena as follows:

"The ductility of mortar will appear when the mortar is associated with metal having an elastic limit considerably exceeding its own, which will consequently contribute materially to the support of the weakest sections, stopping their premature deformation and making each section take the greatest elongation of which it is capable. The reinforcing metal does not change the intrinsic properties of the mortar or concrete, but enables them to produce their resistance simultaneously in all sections, increasing thereby the strength and durability of the structure."

Referring to the same subject, Prof. W. K. Hatt, of Purdue University, makes the following statement in summing up the results of his ably conducted series of tests on reinforced beams. (See Engineering News, February 27th and July 17th, 1902).

"The important fact is the increased extensibility of reinforced concrete in tension. Thus while plain concrete broke with an average extension of 1 : 7000 the reinforced concrete broke with an average extension of 1 :1400. The effect of reinforcement probably is to distribute the maximum elongation over the entire length of the beam, whereas in the case of plain concrete the maximum elongation is confined to the fractured section."

The theoretical analysis given below has been advanced by Prof. Hatt as the result of the tests previously mentioned. The analysis assumes a parabolic distribution of stress for both compression and tension in concrete (an assumption warranted from numerous stress diagrams) and a position of the neutral axis depending upon the percentage of the sectional area of steel to that of concrete. Typical load-deflection diagrams were obtained on which the author calls attention to three characteristic points, viz.: The point where the curve first turns from a straight line, which corresponds to the yield point of other materials. The point of first crack in the concrete, and the point at which the elastic limit of the reinforcing metal is reached; the latter is designated as the point of ultimate strength. The following formulæ, as derived by Prof. Hatt, are applicable when the tensile strength of the concrete is neglected and the stresses are as indicated in Figure 5. The theory is based on the following assumptions:

Sections plane before bending remain plane surfaces, therefore, the distortion of any fiber is proportional to its distance from the neutral axis.

The applied forces are perpendicular to the neutral surface.

The values of the moduli of elasticity obtained in direct tension and compression apply to the material under stress in beams.

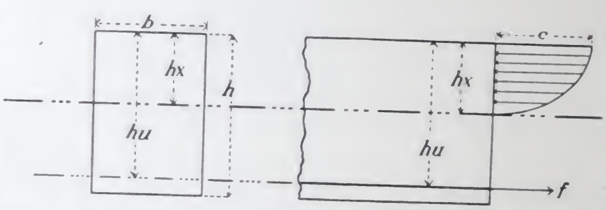


Figure 5

There is no slipping between the concrete and the metal.

There are no initial stresses in the beam due to contraction, etc.

Referring to Figure 5:

Let h = height of beam in inches, and
b = breadth of beam in inches.
hx = distance of compression face from neutral axis.
hu = distance of compression face from center of gravity of metal.
p = ratio of area of steel to area of concrete $= \frac{As}{Ac}$.
c = compressive stress in extreme fiber of concrete.
f = tensile stress in steel.

Es and Ec = moduli of elasticity of steel and of concrete in compression respectively.

x, u and p are ratios.

Equating the tensile and compressive forces of the cross-section we have:

$$\tfrac{2}{3}\, cx = pf \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

According to the first assumption $\frac{c}{Ec} : \frac{f}{Es} :: hx : h\,(u-x)$ and by substitution equation (1) becomes $\tfrac{2}{3}x^2 = \frac{Es}{Ec}\,(u-x)\,p$, from which

$$x = -\tfrac{3}{4}\frac{Es}{Ec}\,p + \sqrt{\tfrac{3}{2}\frac{Es}{Ec}\,p\,\left(u + \tfrac{3}{8}\frac{Es}{Ec}\,p\right)}. \quad (2)$$

Finally, taking moments about the neutral axis the resisting moment is:

$$M = bh^2\,\left[\tfrac{5}{12}\,cx^2 + pf\,(u-x)\right] \quad . \quad . \quad . \quad . \quad (3)$$

Prof. L. J. Johnson, of Harvard University, has pointed out a method of simplifying the above formulæ for practical use (see "The Design of the Steel-Concrete Work of the Harvard Stadium," Journal of the Association of Engineering Societies for June, 1904). By substituting alternately the values of f and c obtained from equation (1) in equation (3) he reduces it to the following forms:

$$\left.\begin{array}{ll} M = \frac{2}{3}\,cx\,(u - \frac{3}{8}x)\,bh^2 & \text{if allowable stress in concrete is assumed} \\ M = pf\,(u - \frac{3}{8}x)\,bh^2 & \text{if allowable stress in steel is assumed} \end{array}\right\} \quad (4)$$

Prof. Johnson then states that the coefficient of bh^2 in equation (4) may be replaced by K, "a numerical coefficient depending for a given u and $\frac{Es}{Ec}$, simply on the steel percentage and can be taken from a table." He also suggests that u be assumed as unity, but it must be remembered that the value of h resulting from this assumption is the distance from the top of the beam to the center of gravity of the reinforcement, and that the actual depth of the beam is obtained by adding a sufficient thickness of concrete below the metal for its complete protection. Adopting the method suggested above we finally have the following working formulæ:

$$\tfrac{2}{3}cx = pf \quad \ldots \quad (5)$$

$$x = -\tfrac{3}{4}\frac{Es}{Ec}p + \sqrt{\tfrac{3}{2}\frac{Es}{Ec}p\left(1 + \tfrac{3}{8}\frac{Es}{Ec}p\right)} \quad \ldots \quad (6)$$

$$M = Kbh^2 \quad \ldots \quad (7)$$

Where $K = \frac{2}{3}cx(1 - \frac{3}{8}x)$ or $pf(1 - \frac{3}{8}x)$, depending upon whether the allowable unit stress for concrete or steel is assumed. The relation of the two is determined from equation (5) and neither must be exceeded.

The constants to be assumed are p, $\frac{Es}{Ec}$, c or f; p is optional and the remainder depend upon the nature of the materials.

The diagram, reproduced on page 9, from Prof. Johnson's article, shows values of K for varying values of $\frac{Es}{Ec}$ and p. These values of K are to be used in proportioning for SAFE LOADS, as a factor of safety has been introduced which allows a maximum compressive stress of 500 pounds per square inch in the concrete and a maximum tensile stress of 16,000 pounds per square inch in the reinforcement. The diagram is inserted to illustrate the method and demonstrate its convenience, and it is manifest that for allowable stresses other than those given above, the K values obtained from the curves will not apply. It is readily seen, however, that by substituting proper values of $\frac{Es}{Ec}$, c and f in the equations values of K may be obtained for any mixture of concrete and the results plotted in a similar manner. In this way data for general use may be obtained that will greatly simplify the operation of finding the resisting moment of a given section, or the section for a given moment.

To facilitate the application of the formulæ to Expanded Metal floor construction, values of p for different depths of slabs are given in Table No. 1 :

Depth of Slab Inches	Values of P for 12 Inches in Width					
	Stock Sizes		Sizes Cut to Order			
	3 Inch—No. 10	6 Inch—No. 4	3 Inch—No. 10		6 Inch—No. 4	
	$\frac{5}{32}$ Inch Strand	$\frac{1}{4}$ Inch Strand	$\frac{15}{64}$ Inch Strand	$\frac{5}{16}$ Inch Strand	$\frac{3}{8}$ Inch Strand	$\frac{1}{2}$ Inch Strand
2	.008	.010	.010	.0150	.015	.020
2½	.006	.0085	.009	.010	.015	.015
3	.005	.007	.0075	.010	.010	.015
3½	.0045	.006	.0065	.009	.009	.010
4	.004	.0055	.006	.0075	.008	.010
4½	.0035	.005	.005	.007	.007	.0095
5	.003	.0045	.0045	.006	.0065	.0085
5½	.003	.004	.004	.0055	.006	.008
6	.0025	.0035	.004	.005	.0055	.007
6½	.0025	.0035	.0035	.0045	.005	.0065
7	.002	.003	.003	.0045	.0045	.006
7½	.002	.003	.003	.004	.0045	.0055
8	.002	.0025	.003	.004	.004	.0055

THE VALUES OF P ARE GIVEN TO NEAREST $\frac{5}{1000}$.

It is a well understood and recognized fact that the resisting moment of a floor slab is greater than given by the formulæ, as the latter apply to beams supported on knife edges and the slabs receive support from the haunches and adjacent panels. It is impossible to give a rational formula for this increased resistance, but from

our experience in the design and construction of floor slabs, and in addition a comparison of the formulæ with the actual results of numerous tests, we may state that the bending moments as obtained from the usual formulæ may be diminished from 10 to 30 per cent., depending upon the mixture of the concrete and the floor system to be adopted.

One of the fundamental assumptions included in every theory advanced on the subject of reinforcing concrete is that there shall be no slipping between the concrete and reinforcement. It is also generally conceded that a uniform distribution of small masses of metal at comparatively close intervals is preferable to concentration of metal at large intervals. In these two particulars Expanded Metal is unexcelled; no argument is needed to prove slipping impossible, the concrete thoroughly fills the meshes, and a more perfect mechanical bond cannot be made between the two materials, it being universally true that the metal will break before it can be pulled out.

The distribution of metal is necessarily uniform from the nature of the fabric, and not the least among its many advantages is that the location of the strands, or reinforcing members, is absolutely fixed and independent of measurements and spacing during construction, which are sources of possible error. Neither can the metal be knocked out of position or otherwise displaced, through ramming or carelessly depositing concrete.

The extensive and varied application of Expanded Metal as a reinforcing medium will be partially revealed by glancing through this catalogue. There is scarcely any form of concrete construction in which it may not enter as an element of durability, safety and economy. Especial attention, in this connection, is invited to Fig. 6 in which a section of the "Price's Run" sewer of the Wilmington, Del., system is illustrated. The sewer is 1726 feet long and Mr. T. Chalkley Hatton, consulting engineer, writes of it as follows in the Engineering Record of May 21st, 1904:

"In the cross-section of the sewer, built through this deep cutting, it will be noticed the thickness of the sewer at the crown is but 8 inches, which is 5½ inches less than the writer has been in the habit of using for a 9 foot diameter arch where the material used was brick. This thickness, however, has withstood the shock resulting from dumping a cubic yard of dirt and rock from the cable buckets at various heights from 3 feet to 10 feet, and the weight of 25 feet of loose filling without any apparent fracture."

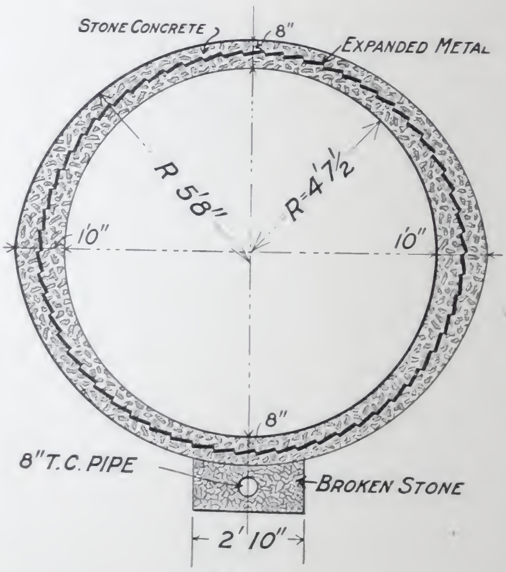


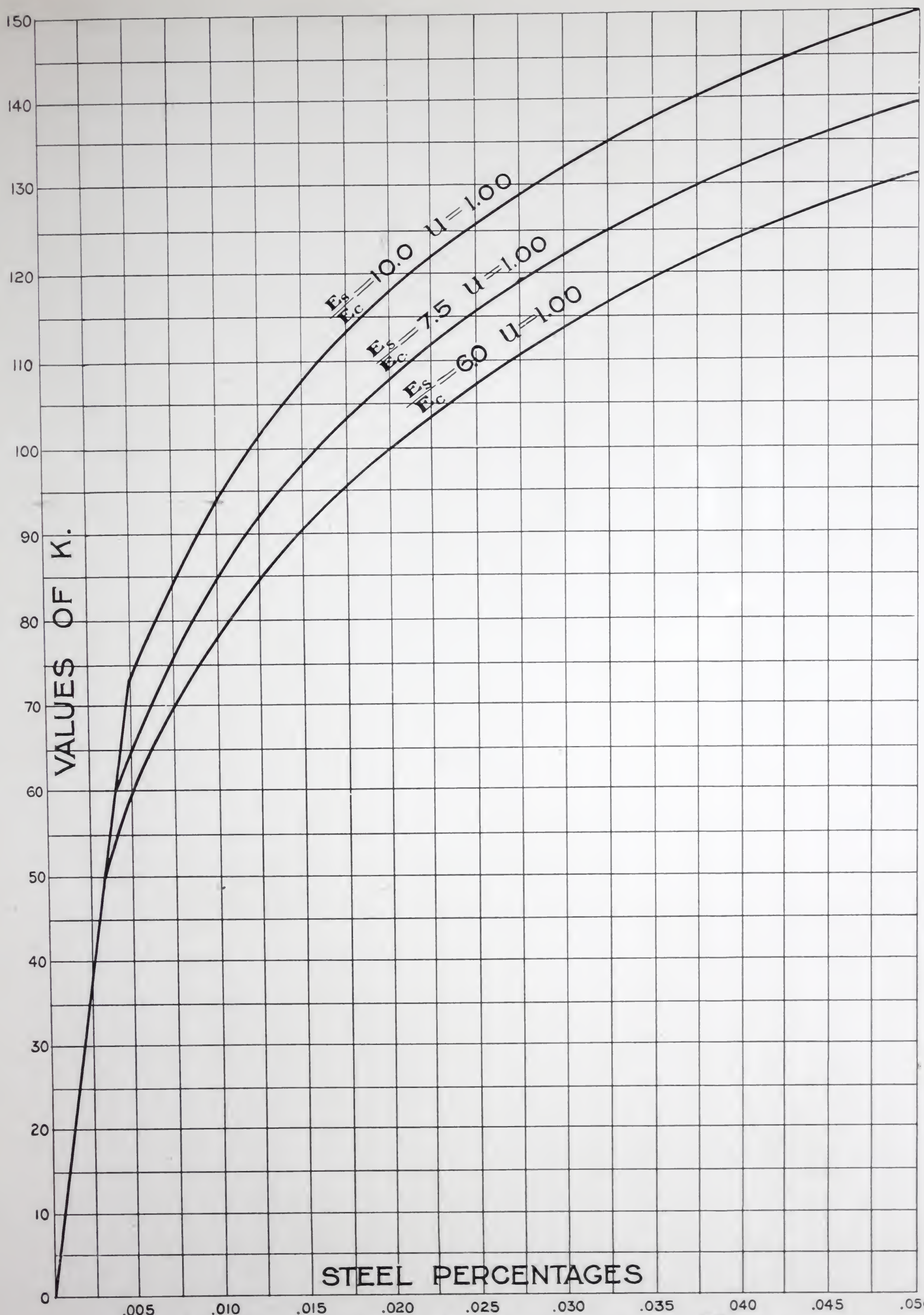
Figure 6

A section of the 10 feet conduit built in connection with the Torresdale, Philadelphia, filter beds is reproduced in Fig. 92. There are 3850 feet of conduits varying from 7 feet 6 inches to 10 feet in diameter, all of the same general design, and built of concrete and reinforced with Expanded Metal. The interesting fact to be noted regarding these conduits is that all are subjected to an internal pressure from 20 feet head of water. On the same subject we may add that the Achères Sewer, Paris, France, consisting of a 4-inch circular shell of reinforced concrete, is 5.9 feet diameter and successfully withstood an internal pressure due to 45 feet head of water.

Illustrations of this character may be multiplied indefinitely, and one may readily realize the utter impossibility of discussing either theoretically or practically the many different applications. We have a staff of engineers who are making an especial study of these subjects, and, are, therefore, prepared and most willing to give the benefit of our experience and research to any one contemplating the use of Expanded Metal reinforcement.

PRACTICAL TESTS

PRACTICAL tests of materials of construction are always interesting and instructive; it may not be out of place, therefore, to insert the following table, containing a few tests of floor panels reinforced with Expanded Metal. Most of these were made on panels in buildings during the course of erection and represent actual, practical conditions, a fact which greatly enhances their value. The list includes tests for strength alone, and might be augmented by a series of successful fire-resisting tests. The latter seem superfluous, however, in view of the many recent reports attesting the good behavior of concrete in the Baltimore fire, some of which are quoted in part on page 10 of this catalogue. The record of tests of expanded metal construction in



Curves showing K's for varying $\frac{E_s}{E_c}$ and u

Figure 7

general is entirely too voluminous to print here, but we will be pleased at all times to give detailed information regarding them and trust that those interested will not hesitate to write for full particulars.

No.	Where Made	Kind of Concrete	Span	Thickness of Slab	Load per Square Foot Pounds	Center Load Pounds	Deflection at Center Inch	Reinforced with Expanded Metal	Remarks
1	N. Y. Sugar Refining Co., Long Island City, L. I.	Cinder	4′	4″	——	40,000	0	3″–No. 10	Returned to original position, load removed.
2	N. Y. Sugar Refining Co., Long Island City, L. I.	"	4′ 10″	4″	——	37,000	3/8″	3″–No. 10	
3	Larkin Soap Factory, Buffalo, N. Y.	"	4′	3″	2,333	——	5/8″	3″–No. 10	"
4	Y. M. C. A. Building, Milwaukee, Wis.	Cinder and Stone	17′ 8″	5″	800	——	0	3″–No. 10 rods 16″ c to c	Top 2″ stone concrete. Bottom 3″ cinder concrete.
5	Edison Power House, New York, N. Y.	Cinder	5′	5″	——	122,500	——	3″–No. 10	Segment arch. Rise 10″, slight crack which closed load removed.
6	Govm't Hospital for Insane, Washington, D. C.	"	6′	3″	1,256	——	3/16″	3″–No. 10	Final load 1,800 lbs. per sq. ft. cracks but no failure.
7	Merchants Refrigerating Co. Warehouse, Jersey City, N. J.	"	7′	5½″	2,400	——	5/16″	3″–No. 10	Failed at 2,420 lbs. per sq. ft.
8	Board of Harbor Commissioners, San Francisco, Cal.	Stone	7′	4″	750	——	0	2½″–No. 16	
9	Columbia University, New York, N. Y.	"	15′	9″	600	——	5/8″	6″–No. 4 ½″ rods	Slab previously tested by fire 1,716° for four hours, followed by application of water at 60 lbs. per sq. inch pressure.

Test No. 9 is a floor slab constructed at Columbia University in New York, and had been subjected to the severe fire test required by the city Building Department before being loaded with 600 pounds per square foot. The load remained on the floor for sixteen hours without any apparent change or the slightest indication of cracks or failure. The test was conducted by Prof. Ira H. Woolson, of Columbia University, and was supervised by representatives of the New York Building Department.

FIRE RESISTING QUALITY OF CONCRETE

THE best school at present for those pursuing the study of fire resisting materials is the Baltimore fire. It is not our intention to go into the subject further than to give an epitome of the lessons learned, accompanied by references to the most noteworthy reports made after careful examinations of the burned district by the respective authors.

In an address before the National Board of Fire Underwriters at New York on May 12, 1904, Capt. John S. Sewell, Corps of Engineers, U. S. Army, says: "Reinforced concrete in the hands of competent designers and good workmen is capable of displacing steel entirely for buildings of moderate heights, and of displacing steel girders, beams and floor members everywhere, with improvement in fire-resisting qualities as compared with current types of structures. But it is too early in the day to hope for general acceptance of this view, although there is not the least doubt of its correctness in the minds of those who have given the subject thorough and impartial investigation."

On the same occasion the well-known consulting engineer, Mr. John R. Freeman, of Providence, R. I., had this to say: "After studying the Baltimore ruins, I am very optimistic on the fire-resisting qualities of Portland cement construction. One great advantage of Portland cement concrete construction is that if you put it in wet and soft, and almost semi-fluid, it will fill the voids and leave no bad 'blow holes' or cavities even under mediocre care and incompetent supervision. The careless workman thus has less chance to get a poor joint than in brickwork. Portland cement concrete possesses far greater tensile strength and shearing strength than the best brickwork, and in brief I believe that it presents a material for fire-resisting construction which is not excelled by anything yet known."

The following quotations are from Report No. XIII, of the Insurance Engineering Experiment Station at Boston, Mass., of which Mr. Edward Atkinson is Director. The title of the report is "The Conflagration in

Baltimore." "Terra cotta has failed. The failure to resist high temperature is due both to the quality of the material itself, which is more or less subject to disintegration under heat, and to its expansion. The greater fault is that terra cotta blocks, plates and other forms are detached by expansion in large masses from the steel. Where concrete floor arches and concrete steel construction received the full force of the fire, it appears to have stood well, distinctly better than terra cotta. The reasons, I believe, are these: First—Because the concrete and steel expand at sensibly the same rate, and hence when heated do not subject one another to stress; but terra cotta usually expands about twice as fast with increase in temperature as steel, and hence the partitions and floor arches soon become too large to be contained by the steel members which under ordinary temperature properly enclose them. Under this condition the partition must buckle and the segmental arches must lift and break the bonds, crushing at the same time the lower surface member of the tiles. Especially in the Calvert Building I found evidence which leads me to believe that not an excessive temperature, but the differential expansion under a moderate high temperature of the terra cotta of the top and bottom members and of the enclosing steel is responsible for the general failure of the terra cotta partitions, beam covering and floor arches. Secondly—Mr. Gray suggests that there is a similar unequal expansion of the top and bottom faces of the separate tiles, which causes the lower faces to expand and shear off. Evidences of this were found everywhere."

"Further examination of the expansion phenomena points to them as the main source of distress to the whole beam and post covering, floor, arches and partitions. Most of the fallen terra cotta partitions and the floor blocks were still hard and had a clear ring when struck, though cracked and broken. There was no evidence of any such temperature as that at which the terra cotta had been baked originally, and the material of the blocks could not have been altered chemically. It will be readily understood that the thin walled hollow tiles would become heated upon one side much more quickly than would the equivalent area of a solid partition of brick or concrete. Terra cotta, cinder concrete, and stone concrete all have about the same heat-absorbing power, or specific heat, and hence the heavier and more solid the partition or floor, in other words, the more material there is in it, the slower will be its rise in temperature and its subsequent expansion.

"I question whether any floor, containing so little material on its outer faces as did these hollow blocks, could remain sufficiently cool in this fire to avoid serious injury from expansion.

"The general condition of the fireproof buildings is such as to indicate to my mind the unfitness of terra cotta for beam and post covering, and floor construction as here used when compared with concrete or brickwork.

"Much has been said about the uncertainty of concrete. The value of concrete in theory is often admitted by those who consider it unwise to use it because of the difficulty of getting the materials properly proportioned, mixed and placed in position. I have never been able to see the force of this. It is quite as easy to lay sound concrete as it is to put somewhat irregular and confessedly brittle blocks of terra cotta into place with proper bonding. The main difference seems to be that poor concrete reveals its weakness when it falls on 'pulling the centers,' while terra cotta is likely to be strong enough to hold itself in position, even when it can do little more."

Similar conclusions to those quoted were reached by the Committee on Fire-Resistive Construction of the National Fire Protection Association.

In conclusion attention is invited to the fact that the reports from which we have quoted were made by men of the highest scientific attainments, none of whom are interested in exploiting any particular fireproofing material or system. On the other hand, they represent the interests of the manufacturers, owners and underwriters, and are, therefore, manifestly unbiased in their search for a fire-resisting material that will give the maximum protection and minimum hazard.

DURABILITY OF STEEL EMBEDDED IN CONCRETE

WE have previously claimed that reinforced concrete is "rust-proof." The term implies not only that the reinforced member as a whole is rust-proof, which is self-evident, but also that the concrete coating is the best known protection for steel against corrosion. To show that we are in good company we desire to outline briefly the results of the most extensive tests ever made on the subject, and to quote the conclusions of a well-known authority. Professor Norton, of the Massachusetts Institute of Technology, has recently completed the tests referred to, in two series. The first set consisted in imbedding perfectly clean steel in concrete, allowing the concrete blocks to set under the usual conditions of practice and then subjecting them to varying conditions of temperature, moisture, and to carbon-dioxide with traces of sulphurous gases and am-

monia. In the second series specimens of steel in all degrees of initial corrosion were similarly treated. Of the latter specimens, Professor Norton says: "The origin of many of the specimens was rather obscure, as the more corroded ones were taken from scrap heaps of steel works, many having been exposed to the weather for several years. Some had been in buildings as part of the structure, some in salt water, some in fresh water, some in damp ground, and the rest exposed to air under various conditions of dampness. The degree of rust on the specimens varied greatly, from a light yellowish stain to a scale more than one-eighth inch in thickness.

"The specimens were of all thicknesses, from 1-50 to 1 1-4 inches. Some were cut dry, some in water, some with mill-fed oil, and some of those cut with oil were cleaned with gasoline and others with alkaline solutions, while a third part were left more or less oily. It was intended that the specimens should include everything met with in regular practice. The specimens were imbedded in concrete so as to be covered 1 1-2 inches in all directions. The mixture for some was 1:2 1-2:5 broken stone concrete, and for others 1:3:6 cinder concrete. Part of the specimens, after the concrete had been allowed to set twenty-four hours in air and seven days in water, were placed in a damp cellar, others out of doors and still others treated in steam and dioxide tanks, called 'corroders.'"

The specimens were left in the "corroders" from one to three months and subjected to the other conditions from one to nine months. Again Professor Norton states as to the results: "Under these conditions (in the corroders), unprotected steel vanished into a streak of rust, but protected by an inch or more of sound Portland cement concrete the clean steel was absolutely unchanged. We can now state further that this same protection is afforded any ordinary structural steel of that degree of cleanliness likely to be found in use for buildings.

"Not one specimen had shown any sensible change in weight or dimensions, except where the concrete had been poorly applied. Some specimens were purposely bedded in very dry concrete, and some in concrete partly set and many of these were not well covered and the steel was seriously attacked where there were voids or cracks. Of the hundreds of specimens of rusty steel examined, not one which had a continuous, unbroken coating of concrete gained or lost anything in volume or weight by treatment which caused the practical destruction of some unprotected specimens. There is one limitation to the whole question, that is the possibility of getting steel properly encased in concrete. Some engineers will have nothing to do with concrete because of the difficulty of getting 'sound' work. This is especially true of cinder concrete, where the porous nature of the cinders has led to much dry concrete, many voids and much corrosion. I feel that nothing in this whole subject has been more misunderstood than the action of cinder concrete. We usually hear that it contains much sulphur, and this causes corrosion. Sulphur might, if present, were it not for the presence of strongly alkaline cement; but with that present the corrosion of steel by sulphur of cinders in a sound Portland concrete is the veriest myth, and, as a matter of fact, the ordinary cinders, classed as steam cinders, contain only a very small amount of sulphur."

Finally, Professor Norton tersely expresses the gist of the whole subject as follows: "*There is one cure and only one—mix wet and mix well.*" The writer suggests that you cut this out and put it in your hat, and all troubles with "unsound" work will vanish. Wet concrete is not only better, but also cheaper, than dry, as the expense of ramming is largely avoided. It must be mixed well and carefully deposited, but the erection of a concrete structure requires no more supervision or skilled labor than the erection of other forms of structure. A steel or wooden frame requires skilled labor and careful supervision during erection, and a flaw in the material or a poor connection will prove just as disastrous as a bit of "unsound" work in a concrete structure.

FLOOR CONSTRUCTION

THE Expanded Metal system of floor construction has been in use for more than ten years past, and has reached that point of development at which it may be called a standard system of Reinforced Concrete. It has been put into use in every type of building known to the structural world. It is not necessary to dilate upon it in general terms. It will be sufficient to bring to the attention of our patrons and friends the clear understanding of methods which have been established by us, and which are now regarded as meeting every known demand. While it is possible to use the metal for floor construction in other ways than those shown on this and succeeding pages, it should be said that those herewith given meet the average requirements. Special information and details of other methods will be furnished on request.

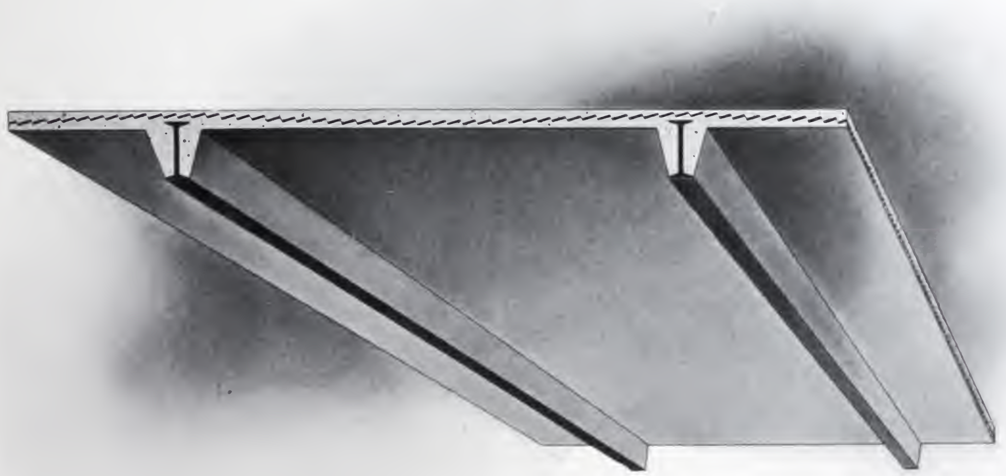


Figure 8

The cut on this page is a view of system No. 3, and is the best adapted form of concrete construction for long or short spans, and for any class of buildings. The beams are thoroughly fireproofed with concrete. The concrete plate may be made flush with the top of the beams, as shown in Figure No. 9, or may come any height over the beams. Screeds may be fastened to the concrete, as shown in Figure No. 9, and the finished floor be nailed to these screeds, or the wood under the flooring may be nailed directly to the construction, as shown in Figure No. 10, if it is cinder concrete. Figure No. 11 shows cement finish on the concrete plate.

If there is no objection to paneled ceilings, the plastering may be applied direct to the under side of the concrete after the bottom flanges of the beams have been wrapped with metal lathing, as shown in Figure No. 9. If flat ceilings are desired with this type of floor construction, channel iron furring may be attached to the lower flange of the beams with clamps, as shown in Figure No. 10, or these ceilings may be lowered to accommodate pipes, etc., as shown in Figure No. 11.

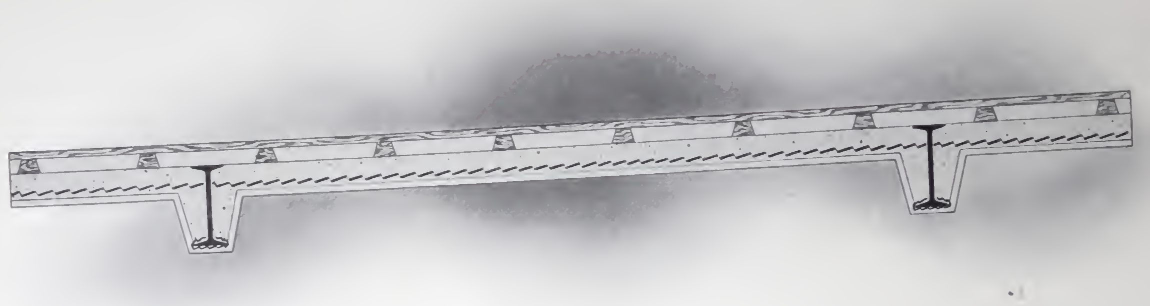


Figure 9

Figure No. 9 shows system No. 3A, which is a popular type where paneled ceilings are desired. The illustration shows the use of screeds, and the single wood flooring space between the screeds being filled with cinder concrete.

Figure 10

Figure No. 10 shows system No. 3B, with an underfloor nailed to the concrete and the finished floor nailed directly to that. It also shows a level ceiling constructed of iron furring, metal lath and plaster.

Figure 11

Figure No. 11 shows system No. 3C, wherein a cement or granolithic flooring is laid directly on the concrete slab. The ceilings are hung low enough below the beams to permit room for pipes or electric wiring.

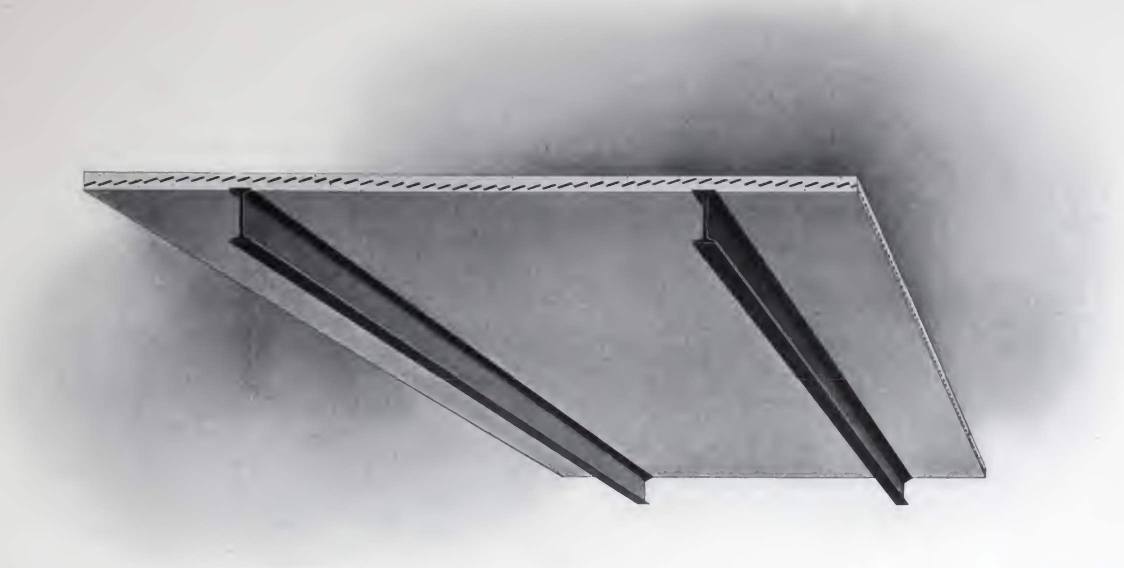


Figure 12

System No. 4, as shown in Figures 12, 13 and 14, can be used with or without the flat ceiling. If it is desired to fireproof the beams, they may be wrapped with metal lathing and plastered. In buildings where there is little combustible material, it is convenient to have the beams exposed for the purpose of attaching pipes, shafting, etc. This system will be found very economical in factories, warehouses, etc., if the flat ceiling is omitted.

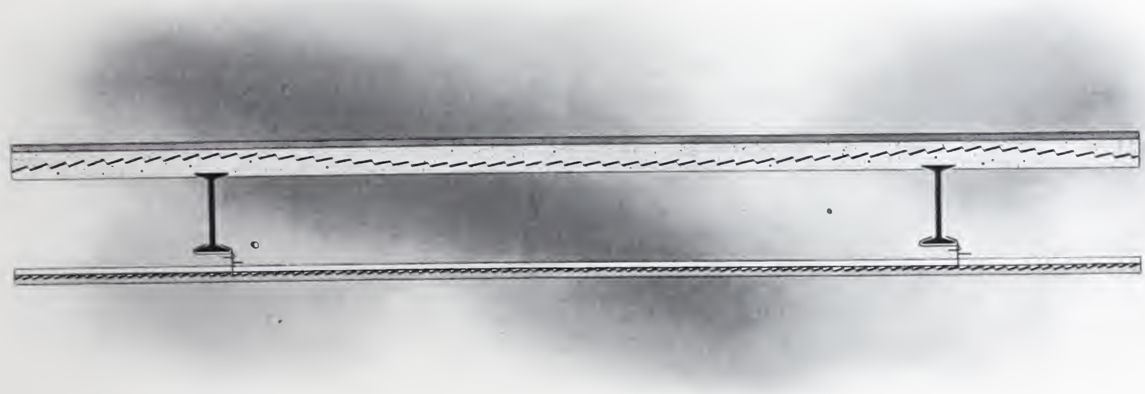


Figure 13

Figure No. 13 shows system No. 4A, with cement-finished floor and space for piping and wiring above the ceiling.

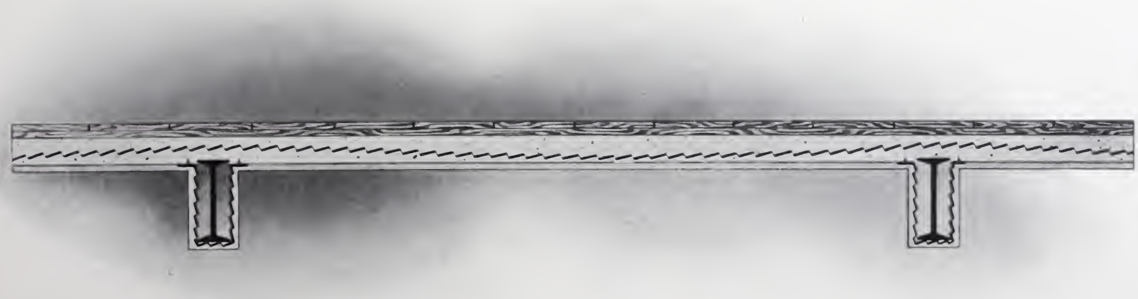


Figure 14

Figure No. 14 shows system No. 4B, with an under floor nailed to concrete, and the paneled ceiling completed by wrapping the beams with lath, which is attached to the concrete and then plastered.

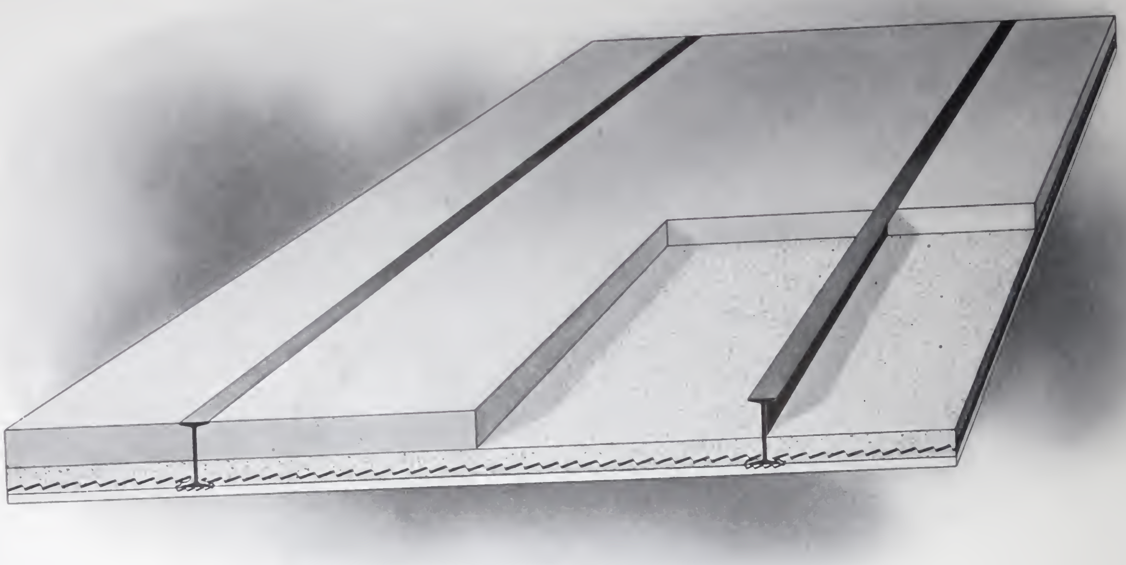


Figure 15

System No. 8 is used in buildings where light loads allow shallow beams of 8 inches or less in depth. It is the most economical system of fireproofing in the market, as it gives a flat ceiling without the use of furring and lathing. Where there are a number of pipes to run, such as in hotels, office and apartment house buildings, screeds should be run over the tops of the beams to allow the necessary space for concealing the piping, but where this is not required the sleepers may be dispensed with, and the underflooring can be nailed directly to the concrete. As the concrete is all laid on centering and thoroughly tamped, a smooth, level ceiling is the result, which can be very economically plastered. Figure No. 16 shows a very satisfactory manner of using screeds, and Figure No. 17 shows the underflooring nailed directly to the concrete.

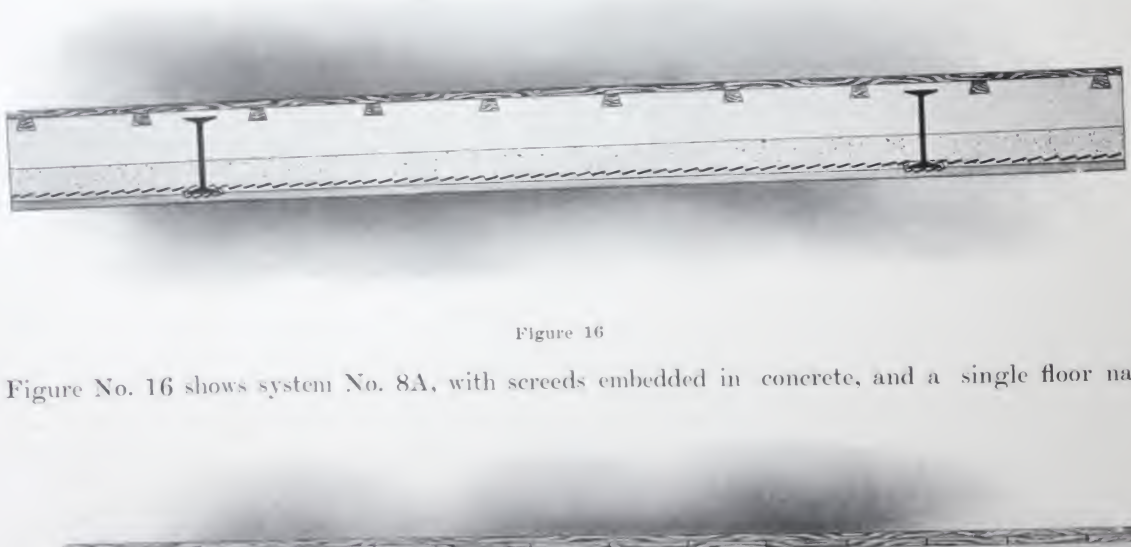


Figure 16

Figure No. 16 shows system No. 8A, with screeds embedded in concrete, and a single floor nailed to same.

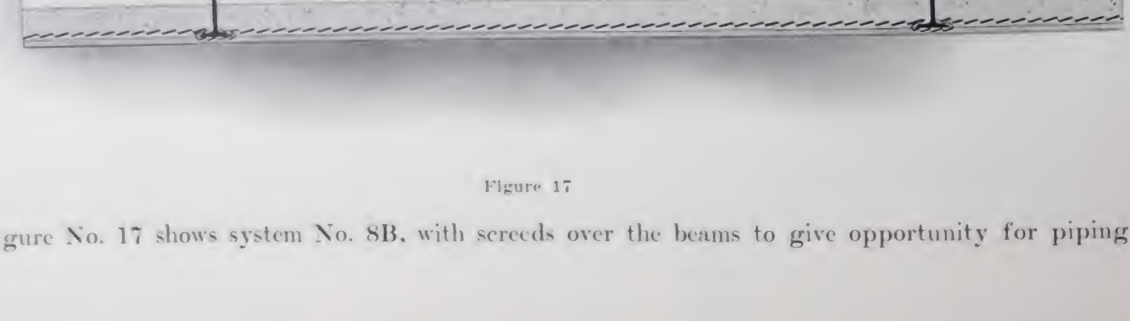


Figure 17

Figure No. 17 shows system No. 8B, with screeds over the beams to give opportunity for piping and wiring.

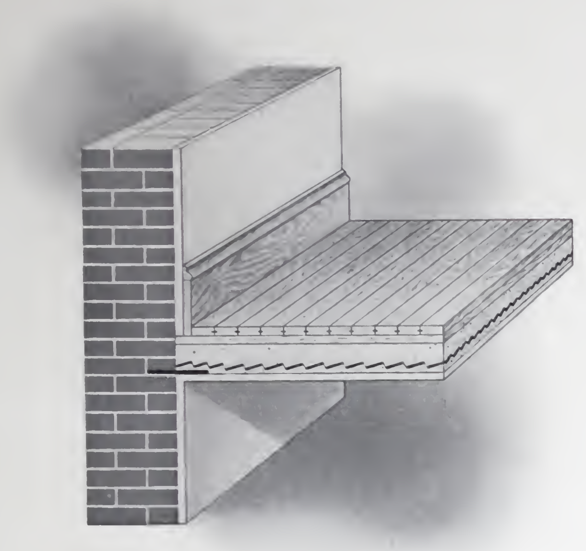


Figure 18

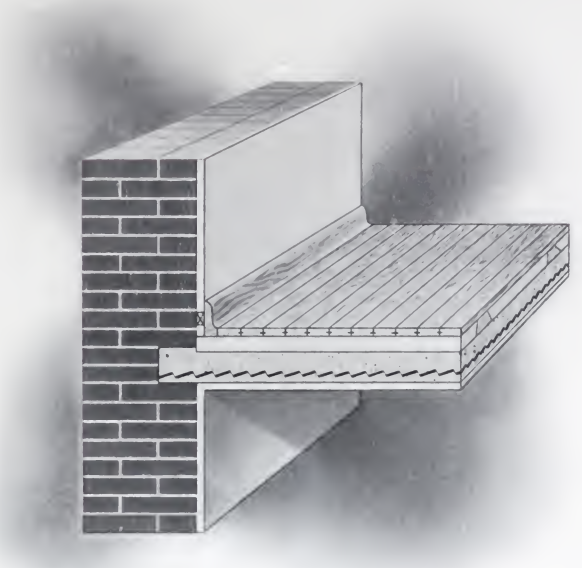


Figure 19

The four cross sections on this page, being Figures Nos. 18, 19, 20 and 21, illustrate four different methods for the support of concrete floors along corridors and places where no steel supports are provided. The details are self-explanatory in the illustrations.

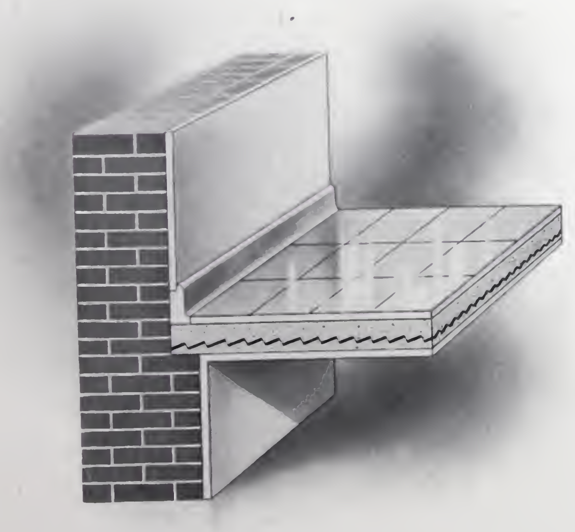


Figure 20

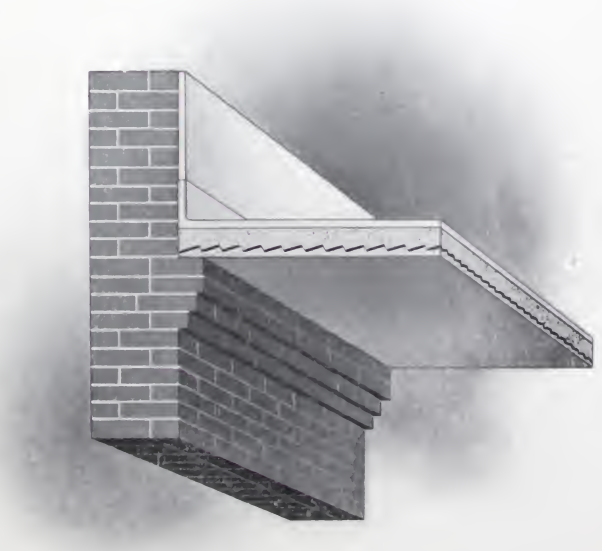


Figure 21

Figure 22

Figure No. 22 shows system No. 3D, as applied to a pitched roof. In this method purlins are spaced 5 to 7 feet apart, resting directly upon the roof trusses. The purlins are encased in concrete, and the slate roof is nailed directly to the concrete. This type of construction is in extensive use in the navy yards of this country, and is regarded as being very satisfactory. It should be stated that the slate roof should be nailed on within two weeks after building the concrete.

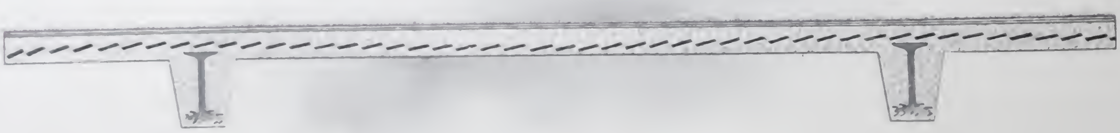


Figure 23

Figure No. 23 shows the same type of construction as applied to roofs built at less than 20 degrees pitch. Roofing material in this case being what is commonly known as tar and gravel, or some form of sheet or plastic roofing. It may be noted that in the first illustration on this page the roofing connects with a concrete and Expanded Metal wall, forming the outside of the building.

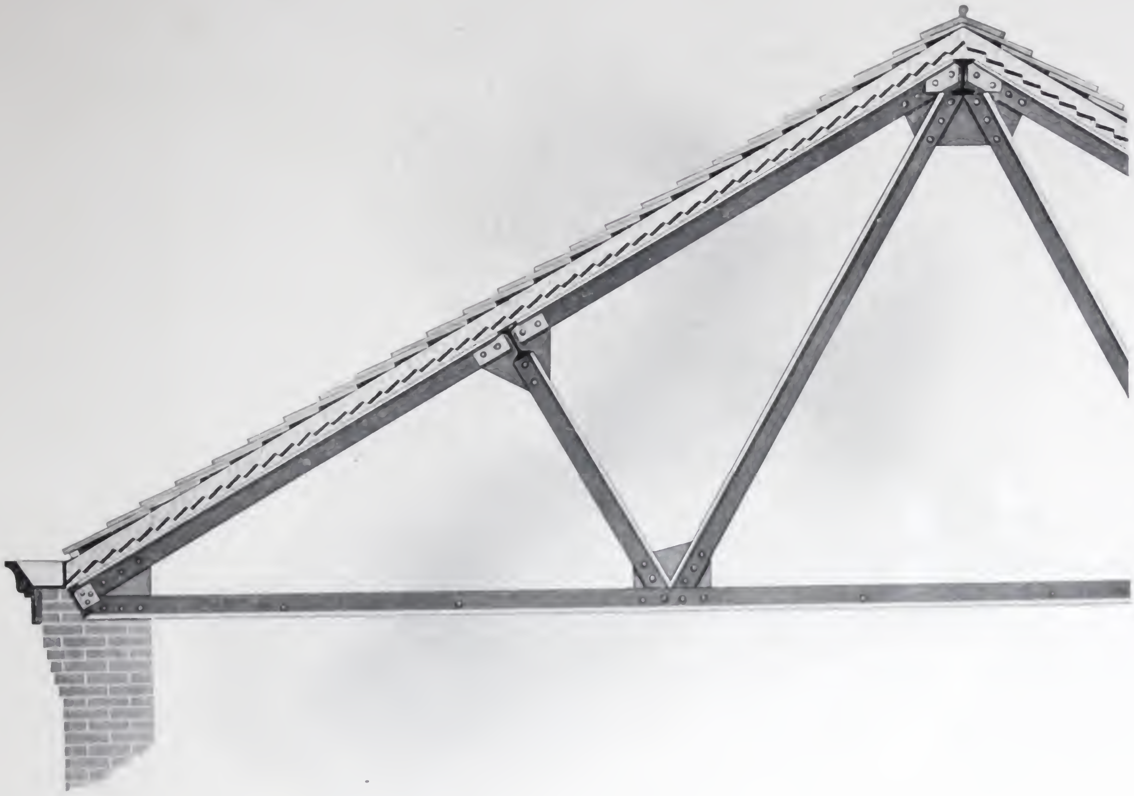


Figure 24

Figure No. 24 shows system No. 4C, as applied to pitched roofs on purlins differently connected with the roof trusses. In this case the roof trusses rest upon the wall of the building, upon which rests also the gutter. The slate roof is nailed to the concrete, as in the previous instance.

Figure 25

Figure No. 25 represents system No. 4D, as applied to a flat roof under similar conditions to those named above, the usual tar and gravel finish being applied.

Figure 26

Figure No. 26 represents system No. 4E, as applied to a pitched roof where the concrete slabs extend from truss to truss, instead of using purlins.

Figure 27

Figure No. 27 shows the same system as described above, only that the roof is flat, ready to receive tar and gravel finish, and a roof on this type of construction may be constructed with trusses 10 feet apart.

PARTITION CONSTRUCTION

Partition construction of expanded metal and mortar is of two general types, viz.: Hollow and solid partitions.

Figures Nos. 28, 29 and 30 illustrate types of hollow partitions. Their many advantages over any other fireproof partitions are self-evident, but among the chief of them may be mentioned:

1. They are very light, strong and economical.
2. Plumbing, steam, gas and electric pipes may be concealed inside without danger from expansion in case of fire, and may be run either horizontally or vertically.
3. As we punch the studs for grounds wherever desired, it is a very simple matter to provide nailings for wood finish.
4. They may be used for bearing partitions, if desired.
5. They can be made any thickness, from 3 inches up, with very slight increase in cost.
6. They are as near sound proof as any partitions can be made.
7. They can be plastered with common mortar, as the studs are stiff enough to require no further stiffening, although cement plaster or any of the patent hard mortars may be used, if desired.
8. As shown in detail, the ordinary method of framing around doors is used, thereby avoiding the use of specially designed frames.

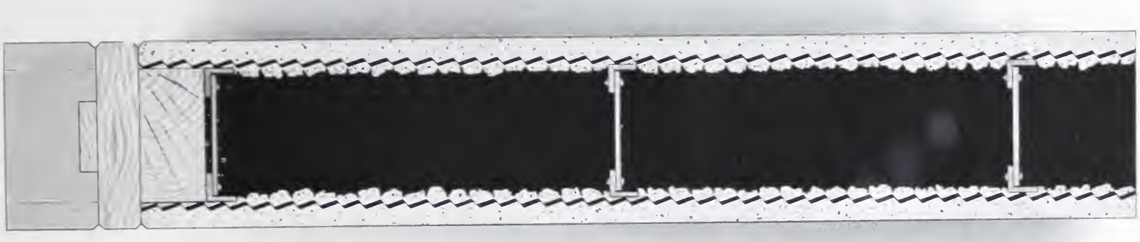


Figure 28

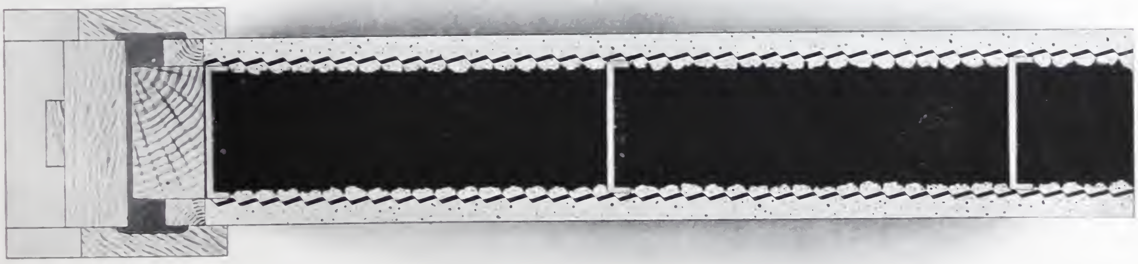


Figure 29

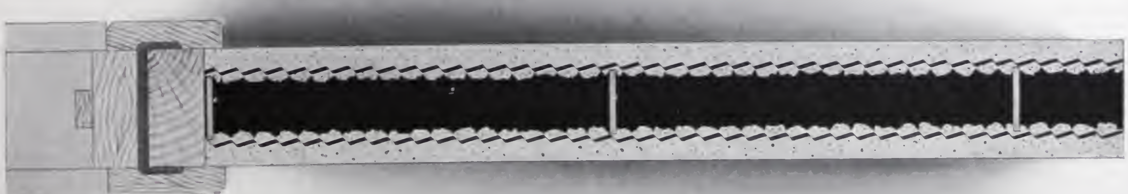


Figure 30

SOLID PARTITIONS

Figures Nos. 31, 32 and 33 show methods of building channel iron and expanded metal solid partitions. Suggestions for wood frames for doors are shown in Figures 31 and 32, and a very satisfactory detail for an iron frame for a tinned door is shown in Figure 33. It is necessary to use a hard plaster or Portland cement mortar to make first-class construction. The partitions are practically sound proof, are light and do not require special framing to carry them, take up very little room and are not expensive. They have been used with success in every class of building.

Figure 31

Figure 32

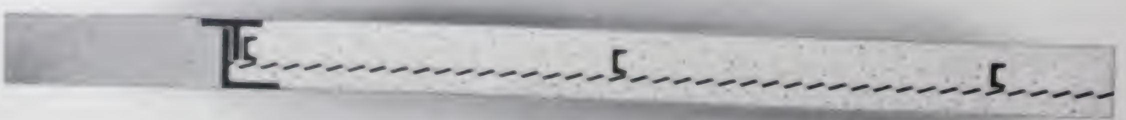


Figure 33

OUTSIDE WALL CONSTRUCTION

Figure No. 34 shows a method of building an outside wall of cement plaster on expanded metal lath and iron studs. This construction stands the weather well, and is warm in winter and cool in summer. Figures 35 and 36 illustrate two methods of building this outside wall on wood studding. When the wall is built as shown in Figures 34 and 35, the plaster on the outside face of the stud is backed up before the lathing is attached to the inside face of the stud, thus entirely enclosing the outside lathing in cement mortar and perfectly protecting it from corrosion. The two sources of cracks in this construction are unequal settlement of the foundation and shrinkage of the wood frame. If the footings are carefully designed and the detail shown in Figure 34 used, both of these dangers are avoided. The detail shown in Figure 35 would be less liable to shrinkage cracks than that shown in Figure 36, which would be subject to the shrinkage of the outside boarding, although this is practically overcome by stapling one-quarter-inch rods to the boarding and securing the lath to them.

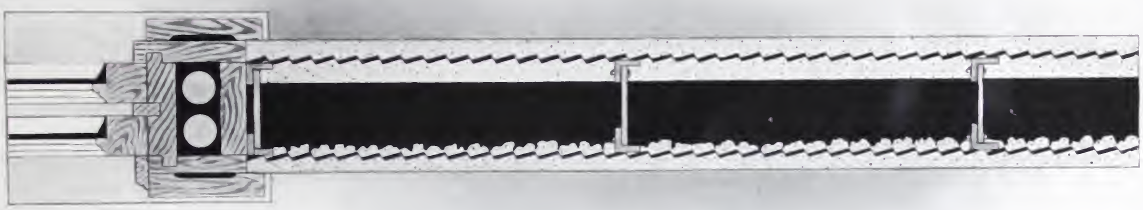


Figure 34

Figure 35

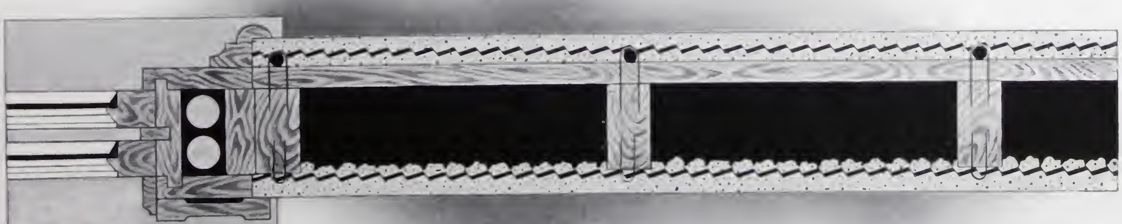


Figure 36

SOLID OUTSIDE WALLS

Figure 37

Figures Nos. 37 and 38 illustrate two methods of building an outside wall of from one and one-half to two and one-half inches of solid Portland cement mortar on expanded metal lath and channel iron studs, Figure 37 showing a steel frame and Figure 38 a wood frame, but both with the framing wrapped with ex-

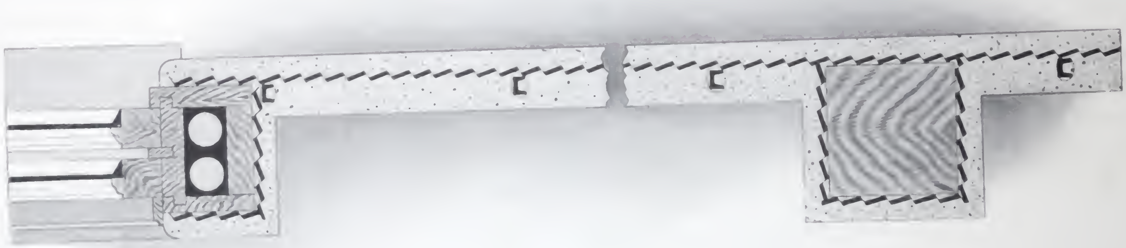


Figure 38

panded metal lath and plastered for fireproofing: though if desired that the building should be fireproof on the outside only, this last precaution could be omitted. This kind of wall has been used on all classes of buildings, and has given good satisfaction.

Figure 39

Figure No. 39 shows a very largely used method of furring an outside masonry wall. The wall is first furred with horizontal channel irons on edge, three or four feet apart, entirely clear of the wall, but leveling it to receive the vertical channel iron furrings, which are attached directly to the horizontal channel iron stiffeners.

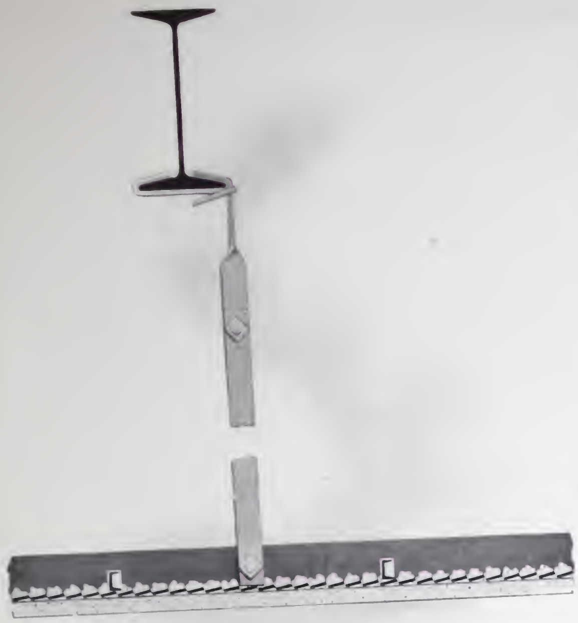


Figure 40

Figure 44

Figure 41

Figure 45

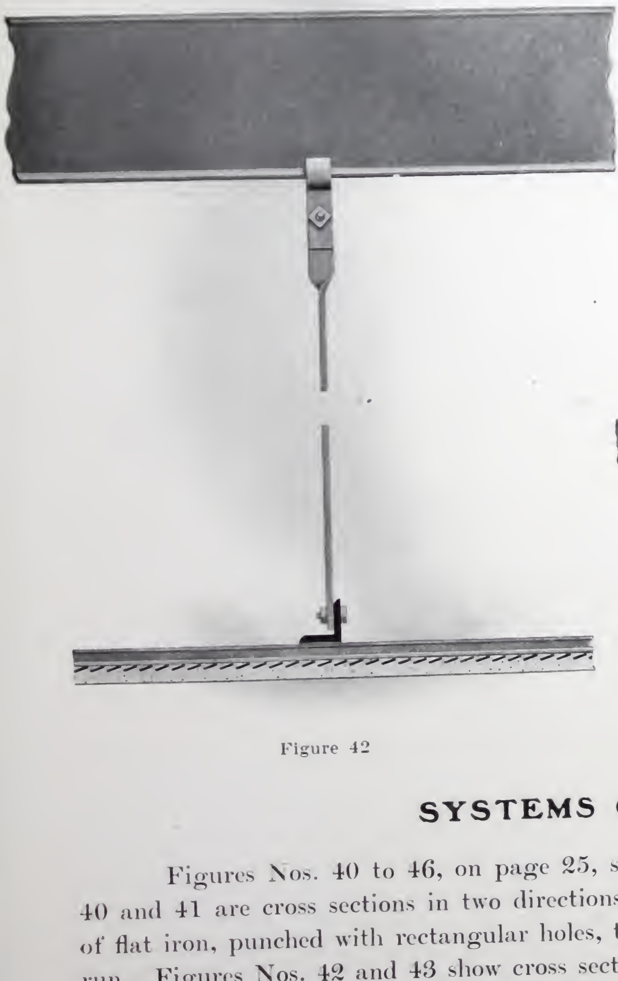


Figure 42

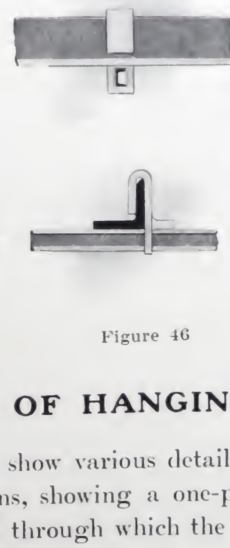


Figure 46

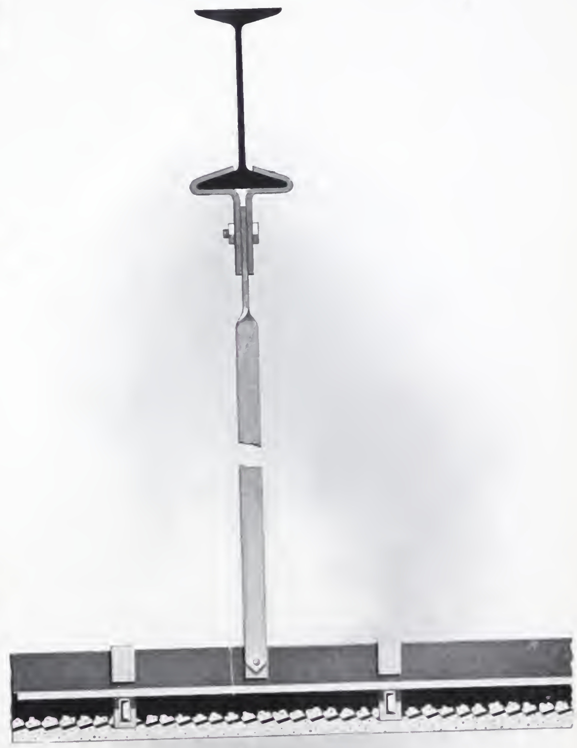


Figure 43

SYSTEMS OF HANGING CEILINGS

Figures Nos. 40 to 46, on page 25, show various details for hung ceilings under roofs. Figures Nos. 40 and 41 are cross sections in two directions, showing a one-piece hanger from the roof beams, and purlins of flat iron, punched with rectangular holes, through which the channel irons with which the lath is secured are run. Figures Nos. 42 and 43 show cross sections in two directions of a two-piece hanger from the roof beams or purlins. The angle iron purlins are bolted to the hangers, and the channel iron furring secured to the angles with the furring clips, shown in Figure 46. Figures 44 and 45 illustrate two kinds of furring clips for securing the furring channels to the purlins when channel iron purlins are used instead of angles.

ORNAMENTAL FURRING AND LATHING

Figures Nos. 47 and 48 illustrate typical details of the use of iron furring and expanded metal lath in ornamental plaster work. Illustrations of elaborate work of this kind are shown on pages 27 and 28.

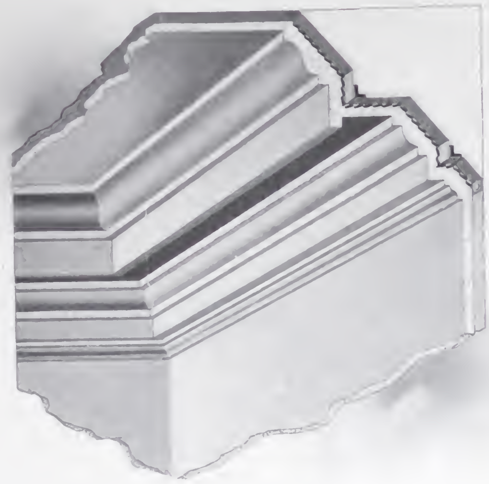


Figure 47

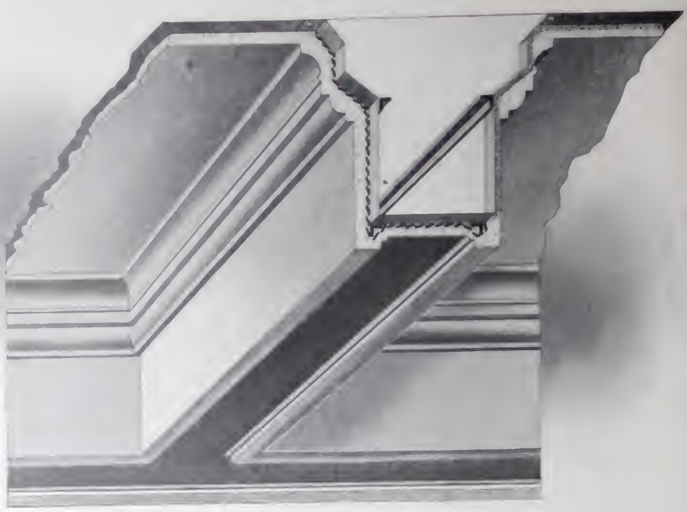


Figure 48

COLUMN FIREPROOFING

Figures Nos. 49 to 52 show typical methods of fireproofing columns. These details are subject to modification according to the degree of thoroughness with which it is desired to have the fireproofing done, as, for instance, Figures 49 and 51 might be shown furred and filled solidly around with concrete, as in Figures Nos. 50 and 52, or Figures Nos. 50 and 52 might be shown wrapped closely with expanded metal lath and fireproofed with plaster, as in Figure 49, and the space inside the lath filled with concrete or not, as desired.

Figure 49

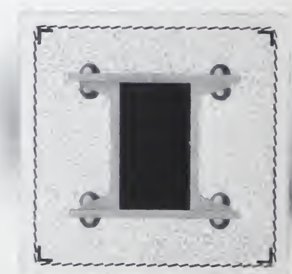


Figure 50

Figure 51

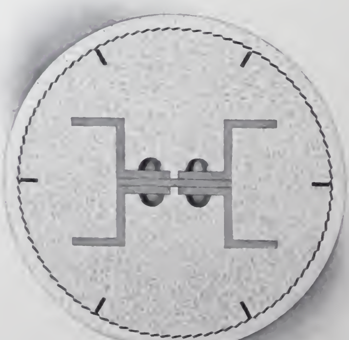


Figure 52

Figure 53

A Pointer or Two

IN the preceding pages have been shown in fairly good detail, various methods for using Expanded Metal as a reinforcing material for concrete floors and roofs, and also for its use as a lathing in the construction of ceilings, partitions and interior fireproofing generally. It should be said that like all other first-class materials this must be used correctly; in other words, with intelligence. By its use there has been developed a specific trade, involving a scientific study of the subject. It can't be put on "any old way." As a lathing material, which is its simplest use, it may be said that there is a right and wrong way of putting on the sheet to receive mortar. By reference to Figures 1 and 2, this fact will be noticed. On a side wall, for instance, lathing should always be put up as shown by these illustrations. On the ceilings the sheets should all be put one way, so that the plasterer may begin at the right side of the area to accomplish his work. In the same manner the heavier mesh in floor construction must be laid with proper laps and tieings to insure desired results.

ORNAMENTAL PLASTERING

The possibilities of accomplishment in the ornamental line with iron furring, expanded metal lathing and plastering, are without limit. As the skill of the mechanic follows the development of the artist's designs, the beauty of the art in real life is increased and multiplied. At this date one of the most artistic features of modern construction is represented by what is wrought out by the combined efforts of artists and skilled workmen. The old day of plain plastered walls and flat ceilings is succeeded by real art in steel and mortar. We show in this connection a few samples of what has been accomplished in various sections of the country.

Figure 53 is an interior view of Corinthian Hall, in Masonic Temple, Boston, Mass. This building contains a number of different halls and lodge rooms, all of which are works of art. The one shown herewith is a clever sample of what may be done. Loring & Phipps were the architects of Masonic Temple, and the work in question was executed by the Eastern Expanded Metal Company, of Boston.

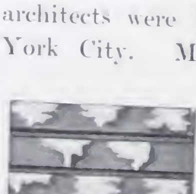
Figure 54 is an illustration of one of the artistic features of one of the famously beautiful theaters of New York City. The picture represents a view in the auditorium of the New Amsterdam Theater, which was built in 1903, and designed by Herts & Tallant, architects, of New York City. The ornamental effects shown in this picture were largely possible by the use of the scheme of construction in question. More than 10,000 yards of Expanded Metal lathing used in this theatre.

Figure 54

Figure 55

Figure 55 represents a corridor in the Bartlett Building, of Atlantic City, N. J. The architects for this building were Messrs. Newman, Woodman & Harris, of Philadelphia. This building is one of the most substantial office buildings on the Atlantic Coast outside of metropolitan cities. It was fireproofed throughout on the expanded metal system, including the ornamental features shown in the picture. The fireproofing was executed by Messrs. Merritt & Co., of Philadelphia.

Figure 56. In this picture is shown the possibilities of ornamental plastering in home building. The view is a staircase hall in the residence of Paul Gilbert Thebaud, and is known as "Hillair." This beautiful residence is located on the heights near White Plains, Westchester County, N. Y. The architects were Snelling & Potter, of New York City. Many thousands of yards of expanded metal lath were used in this palatial country residence.

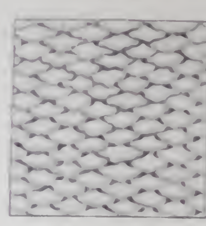


This is
Only Latched

Scores of the best residences throughout the United States have been similarly benefited by the use of Expanded Metal lath.

A PERFECT KEY FOR MORTAR

The excellency of expanded metal lathing is compared with other materials as an absolute guarantee of the only end desirable in the use of a lathing, viz., to clinch and hold mortar. This is its only purpose, and any lath which does not insure these results is a failure. It is impossible to plaster expanded metal without securing a perfect key with sufficient mortar on the reverse side to make this a certainty; and the argument used by manufacturers of sheet metal lathing is that their material saves mortar, which is condemnation of the material itself. It is the mortar which makes the wall, not the lathing. Owners, therefore, are particularly interested to see that the specifications for their buildings call for expanded metal lath, that they may secure the most efficient results in construction. The fact that expanded metal lath has been the standard in government specifications for years is a guarantee of the correctness of the statements herein made.



This is
Keyed Mortar

The above mentioned advantage in the use of Expanded Metal lath is only one of its superior points of excellence. The closeness of the mesh and the abundance of key makes it possible to attach other features of construction without injury to the wall or other portions finished in lath and plaster. In other words, it is possible to nail baseboards, door and window trim and picture moulding to Expanded Metal walls without harm to any portion of the work. The use of Expanded Metal in frame house building has a particular value.

Figure 56

WORK ACCOMPLISHED

IN a few succeeding pages we present illustrations of a number of buildings erected in various parts of the United States and Canada, which have been recently erected and fireproofed on the Expanded Metal system. These few buildings are selected from the many which might be used, and are shown simply as typical of the variety of structures in which our system has been used. The list might be multiplied and many pages filled with similar illustrations, but these few indicate that in buildings of the best type and at the hands of the leading architects our construction has been adopted. In most of these shown the entire work, as applied to fireproofing, has been completed by the use of concrete and Expanded Metal for the floors and roofs, and by the use of Expanded Metal and plaster for the ceilings, walls and ornamental features.

These pages of illustrations of buildings, fireproofed on the Expanded Metal system, might be continued indefinitely, as the buildings which have been thus constructed in the United States and Canada amount to hundreds, and the illustrations of these buildings showing the various classes might be increased many times. There have been fireproofed many of the best buildings in the United States, on the Expanded Metal System, during the last eight or ten years. Expanded Metal has been used in all recent additions to, and repairs upon, the National Capitol, at Washington, the Mint, at Philadelphia, and in most of the government structures during the period mentioned.

Figure 57

FAIRMOUNT HOTEL

The splendid edifice shown in Figure 57 is that of the Fairmount Hotel Building, located in San Francisco, Cal. It is located on "Nob Hill." This building has a location for such a structure scarcely equaled on the American continent. The structure itself was built with the intention that it should be one of the finest hotels in the world. It is owned by Mrs. Theresa A. Oelrichs. The architects were Messrs. Reid Bros., of San Francisco. In this structure nearly 400,000 square feet of Expanded Metal was used in the floors, and a like amount in the ceilings and other features. The fireproofing system was installed by the Western Expanded Metal and Fireproofing Company, of the California metropolis.

Figure 58

KING EDWARD HOTEL

On this page appears a view of the King Edward Hotel, Toronto, Canada, which by all odds is the finest in the Dominion to the north. Mr. E. J. Lennox, of Toronto, is the architect. The interior finish and all appointments are in thorough keeping with the handsome exterior. Nothing in the premier American hostelries can outshine the mural and ceiling decorative work here displayed. This fine house is of fireproof construction throughout, including the roof. Upward of 225,000 square feet of Expanded Metal were used. The total cost was in the neighborhood of $1,500,000, exclusive of furnishing. The fireproofing was erected by the Expanded Metal and Fireproofing Company, Limited, of Toronto.

Figure 59

PENN MUTUAL BUILDING

Figure 59 is an illustration of the Penn Mutual Building, Milk Street, Boston, Mass. In this structure the long-span system of Expanded Metal floors was used, the average span between beams being 17 feet. The total area of the twelve floors and roof was approximately 45,000 square feet. The work was installed within four weeks from time of commencement by the Eastern Expanded Metal Company, of Boston. Messrs. F. C. Roberts and E. V. Seeler were the engineers and architects.

Figure 60

PERMANENT ART BUILDING

In Figure 60 we have an illustration showing a corner view of the Permanent Art Building at the World's Fair, St. Louis. This building was erected on the highest portion of the grounds of Forest Park, and cost $1,000,000. It is to remain as a permanent art gallery, and was built of the best material throughout. The floors and roofs of the building contain 14,000 square feet of Expanded Metal, which was installed by the St. Louis Expanded Metal Fireproofing Company. This building was designed by Mr. Cass Gilbert, of New York, and was erected under the supervision of Isaac Taylor, Director of Works.

Figure 61

BUCKINGHAM HOTEL

The hotel building shown in Figure 61 is the Buckingham Hotel, located in St. Louis, Mo. It was erected near the site of the World's Fair, and the contract, which called for 200,000 square feet of the floors, was executed by the St. Louis Expanded Metal Fireproofing Company in six weeks after the work was commenced. The architect was Mr. H. E. Roach.

Figure 62

UNION TRUST COMPANY'S BUILDING

Figure 62 represents the Union Trust Company's Building, in Providence, R. I. It is one of the best equipped office buildings in New England. It was fireproofed complete on the Expanded Metal system. The architects were Messrs. Stone, Carpenter & Wilson, of Providence.

Figure 63

LAFAYETTE HIGH SCHOOL

In Figure 63 is shown an illustration of the Lafayette High School, Buffalo, N. Y. It is one of the largest high schools in the western part of New York State. In its erection, 100,000 square feet of Expanded Metal was used in the floors, and 5,000 yards of metal lathing in the walls and ceilings. This work was done by the Buffalo Expanded Metal Company. Messrs. Esenwein & Johnson were the architects.

Figure 64

MODERN HOMES

Figure 64 represents one of the most extensive efforts at modern home building in the city of Boston. These houses, numbering sixty in all, including another section on the opposite side of the street to that shown in the picture, were erected within the past year by Mr. W. B. Thomas, Vice-President of the American Sugar Refining Company, and representative of that company's business in Boston. The architect was Mr. Arthur Vinal, of the same city. In the erection of these buildings over 200,000 square yards of Expanded Metal was used.

LAFAYETTE COLLEGE

The illustration shown herewith in Figure 65 was made from a photograph of Gayley Hall, which was presented to Lafayette College at Easton, Pa., by Mr. James Gayley, Vice-President of the United States Steel Company, who graduated from Lafayette in the Class of 1876. The building is one of the group devoted to the study of science, and in this building Chemistry and Metallurgy are to receive special attention. The building was designed by Mr. Charles Bolton, architect, of Philadelphia, who was himself an Alumnus of Lafayette College. The floor and roof construction, as well as the partitions, are on the Expanded Metal system, all of the steel being imbedded in Portland Cement Concrete, and which has proved entirely satisfactory as a protection against the fumes of gases arising from the different tests and demonstrations which are carried on in the various departments. Merritt & Co., of Philadelphia, were the engineers and contractors for the steel and Expanded Metal construction.

Figure 65

Figure 66

ARONSON BUILDING

In Figure 66 is shown an illustration of the Aronson Building, located at the corner of Sutter and Trinity Streets, San Francisco, Cal. It is a mercantile building of the best class and one in which lightness of structure, as well as sunlight and ventilation, were special features. It was fireproofed throughout, including floors, roof, ceilings, columns and partitions, on the Expanded Metal system. Messrs. Hemenway & Miller, of that city, were the architects.

CEMENTINE HOUSE CONSTRUCTION

The use of Expanded Metal lath in connection with cementine house construction is constantly growing in all parts of the country. In California, notably, where the climate is quite well fitted to the use of cement in house building, this scheme of construction is becoming very popular indeed. The architect finds opportunity to diversify his art by the use of cement as compared with wood, and splendid effects are being accomplished. In the use of Expanded Metal lath for this purpose the most desirable method is to cover the exterior sheathing with $\frac{1}{4}''$ round iron rods as furring, over which the lath is then stapled. This guarantees a result not otherwise accomplished.

CARLTON DRY GOODS BUILDING

Figure 67

In Figure 67 is shown one of the modern business blocks of St. Louis, Mo. It is known as the Carlton Dry Goods Building, located at Twelfth Street and Washington Avenue, and was erected at a cost of $600,000 by the company, which uses it exclusively for its business. It contains 225,000 square feet of Expanded Metal floors, put in by the St. Louis Expanded Metal Fireproofing Company. The architects were Mauran, Russell & Garden, of the same city.

In this connection it might be mentioned that in the Baltimore fire, which destroyed a portion of the dry goods district of that city, concrete is entering very largely into the rebuilding operations now going on there. Hollow tile, which suffered so severely and which was condemned so positively by insurance engineers, as well as architectural engineers, has had very little to do with the rebuilding of the burned district of the "Monumental City." Another demonstration made at Baltimore was the non-fireproof value of many kinds of stone used in exterior wall construction. The only two materials which, to any degree, withstood the test were good quality burned brick and hard terra cotta used for trimming. These materials, with concrete floors, make the best combination for mercantile structures.

Figure 68

LARKIN SOAP COMPANY

In Figure 68 is given an illustration showing the evolution of manufacturing business in the city of Buffalo. In the little two-story structure at the left business was commenced by the Larkin Soap Company. The large structure in the center represents a portion only of the plant to-day. For the last five years the company has been building constantly, and in each instance Expanded Metal floors have been installed. The Larkin Company's engineer is Mr. Robert Reidpath, and all the fireproofing was installed by the Buffalo Expanded Metal Company.

POWER HOUSE No. 2, NIAGARA FALLS POWER COMPANY

Figure 69

In Figure 69 is shown an interior view of Power-House No. 2, erected by the Niagara Falls Power Company. In the floors and roofs of this building—including a three-story annex containing the offices of the company, there was installed 75,000 feet of Expanded Metal Concrete by the Buffalo Expanded Metal Company. Messrs. Copeland & Dole, of New York, were the architects, and Mr. William A. Breckenridge was the engineer.

This power house was only one of many in which Expanded Metal has been used as a system of reinforcement for concrete floors. There is no scheme of floor construction which so fully guarantees against vibration as a monolith of steel and concrete. There is another important particular in which the Expanded Metal concrete floor is valuable in power-house construction. Many changes, due to new requirements, demand the cutting of holes in floors. This can be done with perfect safety in floors of our construction, as has been demonstrated many times.

DELTA BUILDING

Figure 70

Figure 70 is an illustration of the "Delta" Office Building, located on Post-Office Square, Boston, one of the best locations in that city. The general contractors for the building were Thompson-Starret Company, and the Expanded Metal was installed by the Eastern Expanded Metal Company, of Boston.

Among the many buildings erected in Boston in which Expanded Metal has been used as the fireproofing system, is one worthy of mention in this connection, namely the New England Conservatory of Music. This institution stands at the head of the musical schools of the United States, and the architects, Messrs. Wheelwright & Haven, of that city, in designing the building accomplished a monument, in an architectural sense, as well as a first-class building, in every point of construction. With a view to making the various rooms sound proof against the adjoining rooms, the floors were built of concrete, with an especially hung ceiling in each instance in order to make an air chamber. In the same manner the partitions were made hollow. In the building in question 140,000 feet of heavy Expanded Metal was used in the floors, and about 20,000 yards of lath. The fireproof construction was executed by the Eastern Expanded Metal Company, of that city.

Figure 71

COAL WASHERY, JOHNSTOWN, PA.

The illustration in Figure 71 shows the Coal Washery and Pitt Building of the Cambria Steel Company, of Johnstown, Pa. Owing to the excessive vibration resulting from machinery used in connection with a number of rapidly running crushers for reducing coal to pea size, which is then washed and stored in the adjoining building, and also to protect the steel from the sulphur in the coal, it was necessary to adopt a system of construction which would meet these unusual conditions. Messrs. Heyl & Patterson, the engineers who designed the building, made a very thorough investigation of the subject, and finally decided to erect a Steel Frame and Expanded Metal construction for the floors and outside walls. The Washery building is 48 feet square and 92 feet high. The Pitt Building is 180 feet long, 95 feet wide and 37 feet high, and contains 20,000 feet of floors and bins, and 38,000 square feet of outside wall construction. This work was all performed by the Expanded Metal Fireproofing Company, of Pittsburgh.

PITTSBURGH RAILWAYS CO. POWER HOUSE

The accompanying illustration (Figure 72) shows the latest power house erected for the Pittsburgh Railways Company. For some years past all of their power buildings have been erected on the Expanded Metal system. This one is located on Brunot's Island, on the Ohio River, about one mile below Pittsburgh. It contains 80,000 square feet of Expanded Metal roof construction, and 30,000 feet of floors.

The completion of this work in so satisfactory a manner by the Expanded Metal Fireproofing Company, of Pittsburgh, has resulted in the adoption of the same system for other important work in the same vicinity.

Figure 72

BUFFALO POTTERY PLANT

Figure 73 is an illustration of the Buffalo Pottery plant, erected in the year 1903. The entire plant was fireproofed by the Buffalo Expanded Metal Company, who used in the concrete floors and roofs of the various buildings 150,000 square feet of Expanded Metal. Mr. Robert Reidpath was the architect and engineer.

Figure 73

Figure 74

BELLEFIELD DWELLINGS

In apartment house building in all cities it has been found necessary to adopt only first-class construction, in buildings of any magnitude. The best of construction was adopted in the Bellefield Dwellings, shown in Figure 74. This building represents fifty-two dwellings, each containing seven rooms, with heat, electric light and refrigerator service, furnished from its own plant. It has a passenger and freight elevator service, operated by electric power. The dwellings have a general clubroom, automobile, bicycle and cold storage rooms. One of the features of these dwellings is that every room in the structure has an outside exposure. The plans were made by Mr. Carlton Strong, the architect, of New York City, and the fireproofing, which comprised 120,000 feet of floors and 20,000 yards of partions, was erected by the Expanded Metal Fireproofing Company, of Pittsburg.

Figure 75

RAPID TRANSIT SUBWAY POWER HOUSE

The illustration shown on this page (Figure 75) represents one of the largest, if not the largest power plants, on the American continent. It is being erected now and nearly completed by the Rapid Transit Subway Company, of New York City. It is located at Fifty-ninth Street and North River. Its general dimensions are 690 feet in length, 200 feet in width and 125 feet high. The immediate installation of power plant includes seventy-two boilers, each with 6,000 square feet of heating surface. These boilers are to supply nine engines having an average horse-power of 10,000 each, which are connected with generators furnishing 5,000 KW. The architects for the building were McKim, Mead & White, of New York. Mr. John Van Vleck was the mechanical engineer. The building was erected by Mr. J. E. Thomas, supervising engineer, and in the erection of the floors, roofs, coal pockets, walls, and other features of reinforced concrete in the building, there was much used over 400,000 square feet of Expanded Metal. The main concrete work was installed by Gallick & Smith, of New York.

Figure 76

HEMENWAY CHAMBERS

Figure 76 is an illustration of one of the choicest apartment hotels in Boston, and is located on Back Bay Park. It is known as the Hemenway Chambers. The architect was Mr. John Lavalle. In this building our No. 8 system of floors was used to the amount of more than 150,000 square feet. Throughout the building 2″ solid partitions were used except between suites, where hollow partitions were used. In the construction of partitions, ceilings and other kindred work 25,000 square yards of Expanded Metal lath were used.

OTHER BUILDINGS

On the foregoing pages are illustrations and descriptions of some of the recently constructed buildings in which Expanded Metal has been used for various purposes. We have previously illustrated from time to time, in special publications, other buildings, some of which are of national interest. We beg leave to call attention again to some of these, not merely to show the extensive use of Expanded Metal, but to point out and emphasize its staying qualities. Our material was used in the following buildings, which have been completed and occupied from two to eight years:

The Congressional Library, Washington, D. C.

The Leonori Apartment Hotel, New York, Buchman & Fox, Architects.

Mills House No. 1, New York, Ernest Flagg, Architect.

Cambridge Hotel, Boston, Mass., W. T. Sears, Architect.

Marlborough Hotel, Boston, Mass., W. T. Sears, Architect.

Massachusetts Horticultural Society Building, Boston, Mass., Wheelwright & Haven, Architects.

Engineering Building, Harvard University, Cambridge, Mass., Shaw & Hunnewell, Architects.

Providence Public Library, Providence, R. I., Stone, Carpenter & Wilson, Architects.

St. Nicholas Hotel, St. Louis, Mo., Adler & Sullivan and C. K. Ramsey, Architects.

Century Building, St. Louis, Mo., Reader, Coffin & Crocker, Architects.

The Coliseum, Chicago, Ill., Frost & Granger, Architects.

Rialto Building, San Francisco, Cal., Meyer & O'Brien, Architects.

Union Ferry and Depot, San Francisco, Cal., E. R. Swain, Architect: H. C. Holmes, Engineer.

FACTORY CONSTRUCTION

THE subject of factory construction is one of the most important in the whole range of building operations. In this country a factory, in the common use of the term, has always meant any building in which men and machinery might be combined to produce an article of merchandise. By virtue of a very frequent limitation of capital in building a factory it has been a common practice to erect a structure wholly from a standpoint of economy. In the ordinary instance permanence, durability and safety from fire are factors too little considered in planning for the home of American manufacture. However, statistics are demonstrating that the fire risk is too great to permit the so-called economic wood construction. For the last five or ten years very considerable advance has been made in the character of the American factory. It has been demonstrated that a building can be erected for factory purposes that shall be practically safe against the ravages of fire. The efficiency of concrete as a fire-resisting material having been fully established, and the economic combination of steel and concrete having also been proved, it is now the effort and study of engineers and factory designers to bring about better results than before.

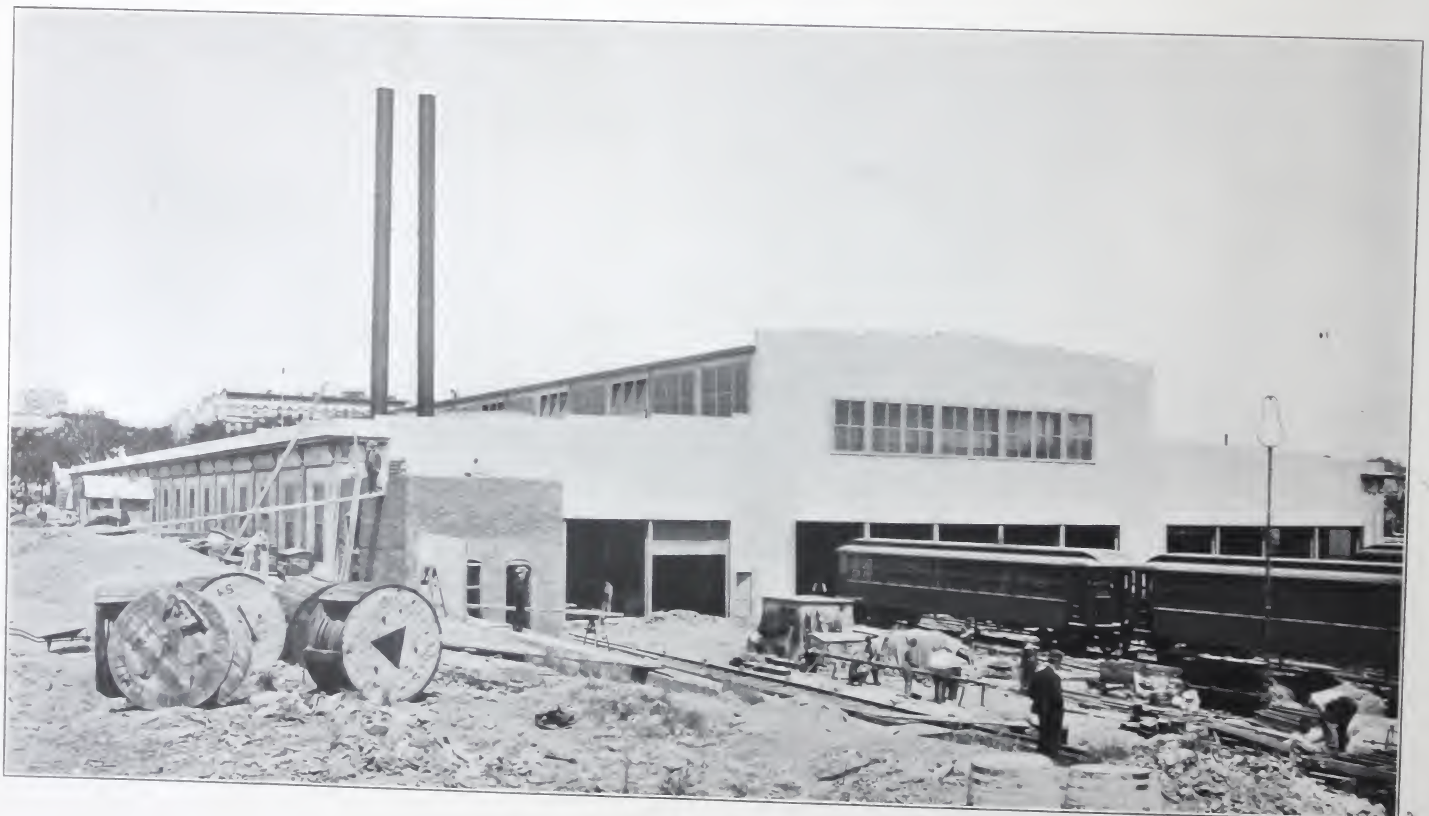


Figure 77

The Expanded Metal companies have done much towards bringing about a betterment along these lines; vast improvements having been made in the details of construction, enabling the use of Expanded Metal as a reinforcement for concrete floors, roofs and walls, so that to-day it is possible to erect a building for factory purposes that is practically safe. In many instances the designers and owners prefer the use of brick walls, while for certain classes of buildings light cement walls for the outside of the building are entirely satisfactory. It is possible to encase in concrete all the columns, beams and other supporting members of the steel frame, so as to render them secure against any fire caused by the burning of the contents of the building.

In this connection we show in Figure 77 an illustration of the recently constructed repair shops of the Rapid Transit Subway Company, of New York. This building is 320 feet in length by 200 feet in width. It was designed by the engineers of the company as to size, form and general arrangements, after which a contract was let to the American Bridge Company for the steel frame. A contract was then let to Messrs. Tucker & Vinton, concrete specialists, of New York, to complete the building and render it as near fireproof as possible. The floors

and roofs were built of the regulation type of Expanded Metal concrete, and the columns were properly treated, while the outer walls were made of light iron, Expanded Metal lathing and $2\frac{1}{2}''$ of cement mortar. Details of the outer wall and its connection with the roof is shown in Figure 78. These details are simple, but in the hands of competent builders are easily obtainable.

It should be said in this connection that all the windows and door-frames were made of wood, covered with galvanized iron, thus making it impossible to injure the structure from an ordinary fire within.

This method of construction is applicable to buildings of three stories in height with economic results. Reference might be made to a dozen or more locations where this type has been adopted. Two buildings erected as inspection sheds for the Elevated Railroad system of New York. These two were located on the elevated structure and in every way answered the purposes of the company. Elsewhere in these pages reference is made to a large coal washery plant erected for the Cambria Steel Company, of Johnstown, Pa. See Figure 71.

A very large factory was erected for the Boston Bridge Company, on the same style of construction. Several shops have also been built for the Erie Railroad Company, at various points on their line, besides many factory plants in various parts of the United States.

A few years ago an entirely new plant, consisting of a series of large buildings, was erected at Steelton, Pa., by the Pennsylvania Steel Company, which consumed several hundred thousand feet of Expanded Metal, and this was only adopted after a careful study of the subject by the engineers of that company.

In Fig. 80 we give an illustration of a one-story building in course of construction on this system for Morse & Whyte Co., of Boston, Mass. This building was only one of the several built for this company, and the photograph was taken after the first coat of cement plaster had been applied.

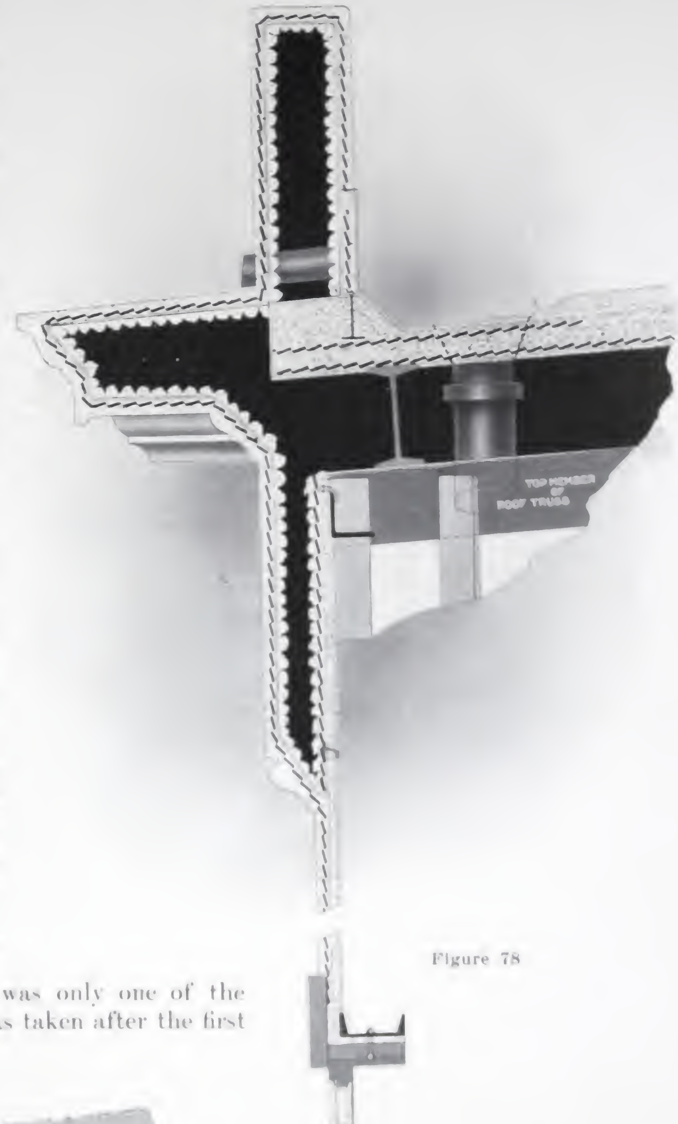


Figure 78

Figure 79

A CONCRETE FENCE

In connection with the building of the shops of the Rapid Transit Subway Company, shown on the adjoining page, there has been erected a reinforced concrete fence, built directly upon a retaining wall surrounding the yard of the plant. The illustration clearly shows the method of construction. The regular method of solid partition construction was followed, by putting up metal studs $12''$ on center, to which Expanded Metal was attached. At distances of $7'$ bracing members were attached to the studs, and the whole encased in cement mortar. The result was a very effective and satisfactory combination.

LEHIGH VALLEY RAILROAD SHOPS

Figure 80

SAYRE, Pa., being practically the physical center of the Lehigh Valley Railroad system, the company decided to erect the new shops with a view to centralizing the building and repairs of motive power, and under the able direction of Chief Engineer Walter G. Berg and plans of Architect E. De Bevoise Brown, have about completed the largest, most modern and up-to-date railroad shops in the United States, if not in the world. After spirited competition, Expanded Metal and Concrete roofing was adopted by the Chief Engineer, and Merritt & Co., of Philadelphia, were awarded the contracts for this work, there being nearly ten acres of the same; Mr. F. D. Hyde, No. 7 East Forty-second Street, New York City, being the general contractor for the main locomotive shop, blacksmith shop, storehouse and lavatory buildings; James Stewart & Co., of Pittsburg, the general contractors for the large power-house, and the Exeter Machine Company, of Pittston, Pa., general contractors for the ash pockets, which will be built of steel, Expanded Metal and Concrete.

Figure 81 shows a view looking down on the saw-teeth or north lights of the main locomotive shops. This is taken from the Monitor on left-hand side of view, Monitor on right side being shown in the distance. This building is 748′ by 363′, containing thirty-two of the saw-teeth. The channel purlins are about 6′ center to center, on which are laid 3″ mesh No. 10 Expanded Metal, and 3″ of cinder concrete, and on top of the latter is laid the Warren-Ehret felt and slag roofing. The ends and gables of saw-teeth are enclosed with light channel studs, 12′ center to center, lathed with Expanded Metal lath, and plastered with Portland Cement mortar, finishing 2″ thick.

All of the work on the building has been carried on under the supervision of Mr. E. H. Shipman, resident assistant engineer, and is fast nearing completion. Many ingenious methods of construction have been employed, and a high order of engineering skill displayed, and with the vast system of ducts and tunnels of Expanded Metal and Concrete for the use of wires, heat, air, etc., not a single unit of economy or usefulness has been overlooked, and when all assembled, each in its place, will give a harmonious whole, and result in a triumph in modern up-to-date railroad shop building.

Figure 81

Engineering Uses of Expanded Metal

IN the preceding portion of this catalogue the use of Expanded Metal in building construction has been described and illustrated in as full detail as seems needful: other references have also been made indicating the great extent and variety of purposes for which the material has been adopted throughout this country. In the succeeding pages we will make an effort to indicate, in a limited space, the use that has been made of it in engineering structures other than buildings. In a word this unique material has a wide field as a reinforcing element of concrete and may be advantageously applied wherever concrete is used. The limit of its possibilities, therefore, has not been approached, and for this reason, that which is shown is merely suggestive; indicating actual accomplishment as a means of pointing to what may yet be accomplished. It may also be said in this connection that the laws governing its use from a scientific standpoint, as given in the early pages of this book, when properly applied will make possible the solution of most every problem likely to arise.

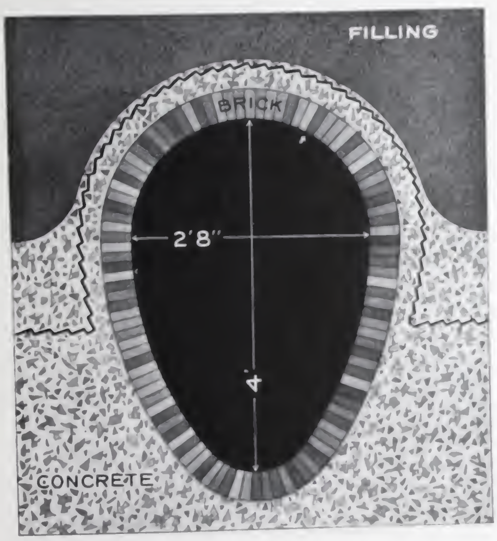


Figure 82

SEWERS

IN the building of sewers having a greater capacity than say a circle 3′ in diameter, it scarcely ever occurs that two different instances furnish the same conditions, hence the sewer engineer has a constant problem before him in designing. In one instance it's a case of difficulty to be overcome in construction by virtue of the surrounding circumstances, and in another it's internal pressure, in another it's external pressure, while in still another it is a question of carrying capacity with the least depth. So that any combination of materials which enables him to overcome the most conditions is a matter of the greatest importance. In Figure 82 we show a not infrequent difficulty, one of the first which Expanded Metal enabled the engineer to overcome. In the case in question the difficulty was that of insufficient depth to allow a fill on top of the sewer to prevent bursting, due to water pressure at the initial end of the sewer. The case in point was in Boston, where Mr. William M. Brown, Chief Engineer of the Metropolitan Sewage Commission, was, after careful examination of the subject, induced to make a trial of reinforcing the conduit cover with Expanded Metal. This was accomplished as shown in the illustration, and although it has been in use for more than four years, no instance of bursting has occurred.

In Figure 83 is shown another condition occurring in New Jersey. In this case it was a question of large capacity with a shallow sewer, requiring also a top as thin as possible. This difficulty was overcome by the engineer, Mr. Lemuel Lozier, in the town of Hackensack, N. J. The design shown in the figure indicates the simple manner in which his trouble was done away with.

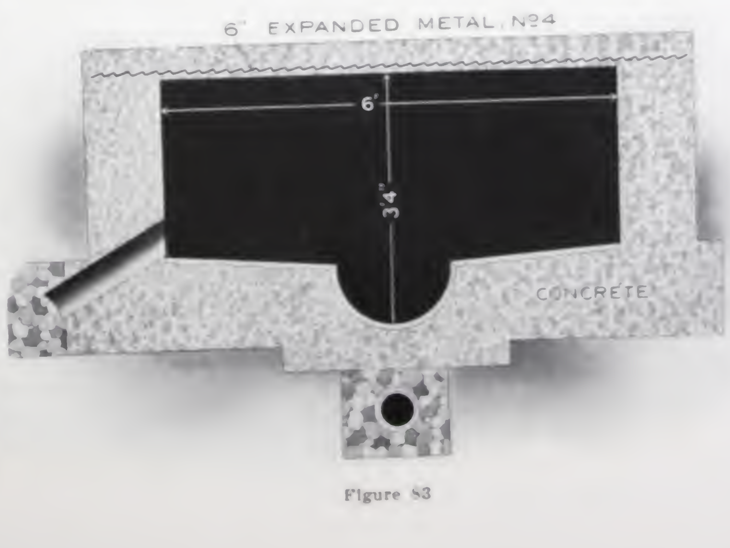


Figure 83

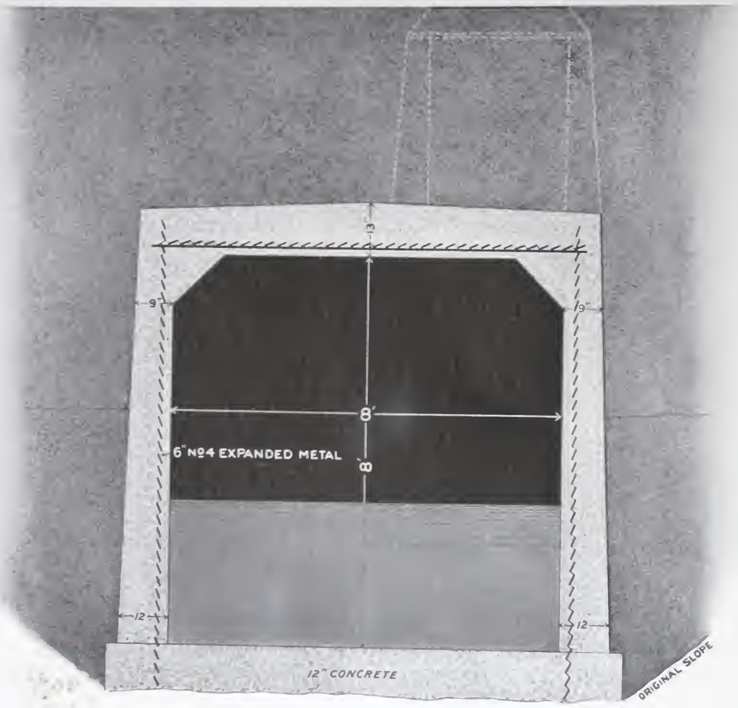


Figure 84

In Figure 84 is shown an illustration of a private sewer, or what is practically so, which was built some years ago by the Lackawanna Steel Company, at Buffalo, N. Y. It is termed by them a "return water drain," being used by them for the purpose of discharging water from the rolling mills and other parts of their extensive plant. It carries all kinds of surplus liquids from their factory grounds to the river. The dimensions are indicated on the drawing, aside from its length, which was nearly one mile. As indicated, this was built on old ground over which a very considerable fill of earth was laid, upon which railroad tracks and buildings were located. The engineer who designed this construction was Mr. C. R. Neher, and the design was approved by Mr. C. C. Conkling, engineer for the Lackawanna Steel Company.

A very unique combination of Expanded Metal and concrete was made use of in the construction of the Boston Subway. In the portion of this tunnel which runs under the river, connecting the city of Boston proper with East Boston, a distance of 1,500 feet, it was necessary to furnish a special scheme of ventilation. This was done by suspending what might be termed a curtain, hung from the top of the arch and attached to the two sides of the tunnel. This was needful to furnish an opportunity to carry off the foul air in the tunnel by means of fans built at either end, the air being drawn through openings in the curtain, which was constructed of 3" No. 10 Expanded Metal, imbedded in $1\frac{1}{2}''$ of Portland cement concrete in the proportions of 1 to 3 of cement, sand and very finely crushed rock. There was used in all 75,000 square feet of metal.

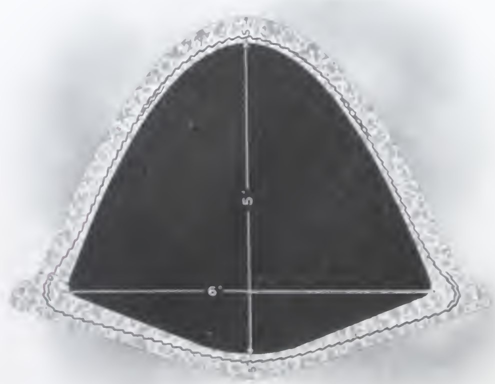


Figure 85

In Figure 85 is shown a cross-section of a sewer designed by Jas. H. Fuertes, Sanitary Engineer, of New York City, and constructed by S. M. Neff, of the same city, in Harrisburg, Pa. This sewer is some three miles in length and was erected to take the place of an old open creek which had been in use for many years, and hence the difficulties of construction were many. The details of the illustration clearly give the manner of the use of Expanded Metal for reinforcement.

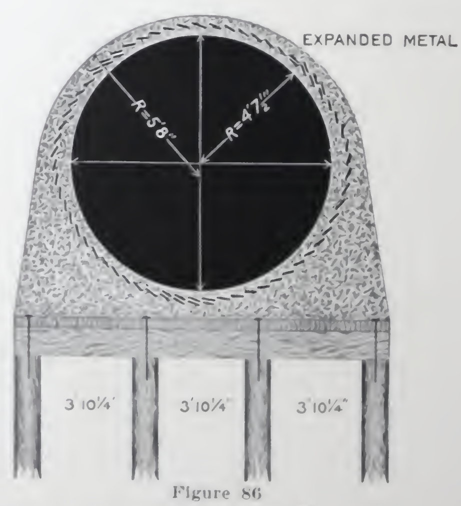


Figure 86

In Figure 86 and Figure 89 are shown two illustrations of a reinforced concrete sewer at Wilmington, Del., which was designed by T. Chalkley Hatton. This sewer was 7,500′ in length, a portion of which had an internal diameter of 9′ 3″, another portion 6′ 6″, and in varying sizes down to 4′ 9″. Its purpose was to carry to tidewater the sewerage and waste water from a portion of the city, amounting to over 600 acres.

In Figure 87 is shown a cross-section of a sewer built in the Borough of Brooklyn, by Henry R. Assarson, Chief Engineer of the Department of Sewers, of that borough. This portion of the sewer was in reality an extension of a large circular sewer which had to be carried out on an especially constructed pier in order that the sewerage be delivered free from mud and sand and emptied into tidewater. A portion of this distance was through the middle of a street, so that it was impossible to build it of the original diameter. It became therefore, necessary, in a sense, to flatten out the sewer, hence the adoption of this design, and the erection of a pile pier wide enough to carry the triplicate section shown. The mass of concrete as indicated was tied together by the use of 6″ No. 4 Expanded Metal.

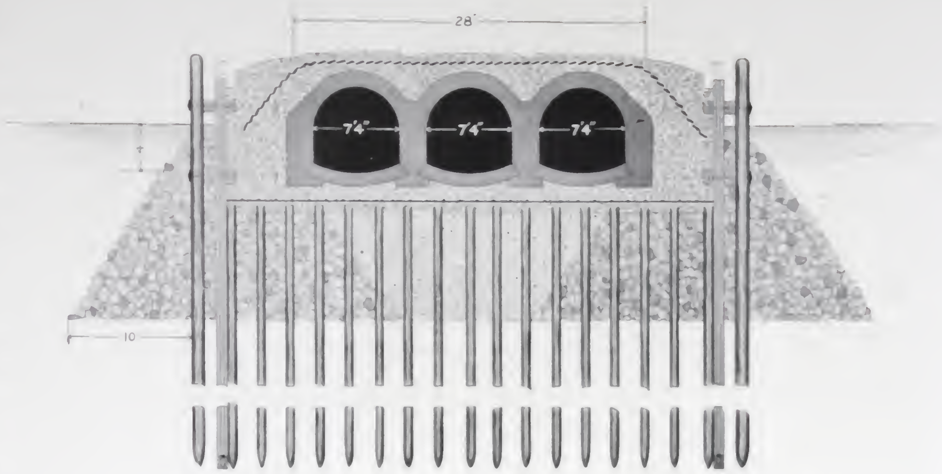


Figure 87

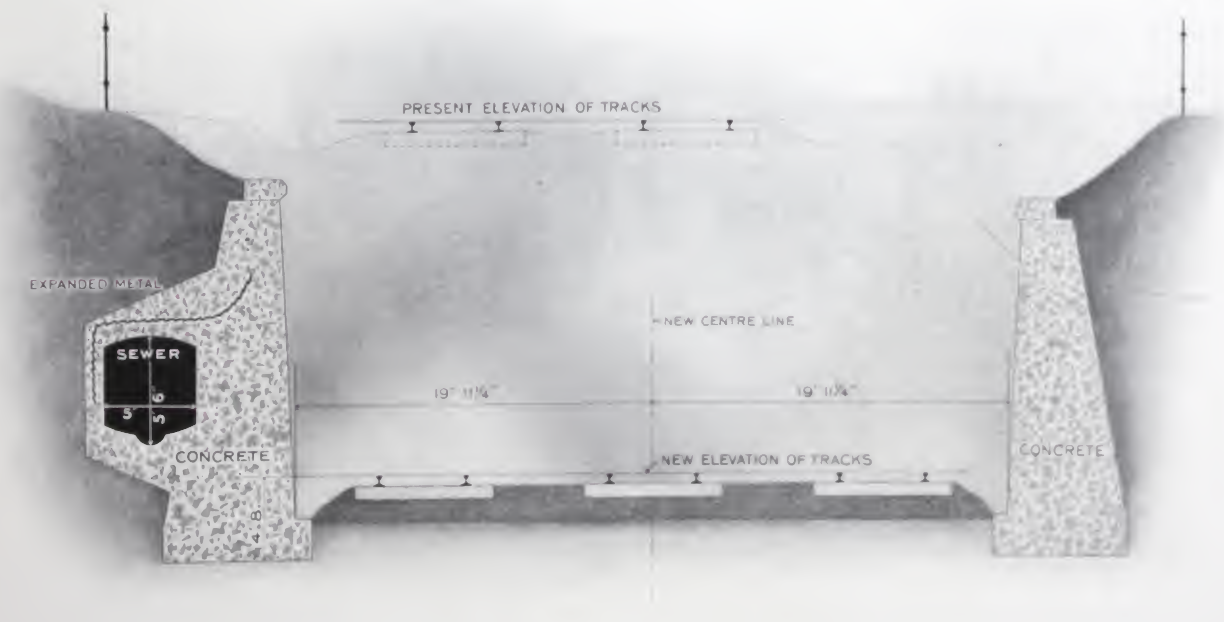


Figure 88

In Figure 88 is shown a very unusual location for a sewer. This occurred in the year 1903 in the city of Newark, N. J. A very important improvement was being made by the D., L. & W. Railroad Company, who were lowering their tracks for a distance of about two miles through that city. Over a large portion of this distance it was necessary to co-operate with the city authorities in the disposal of the sewerage question. This was accomplished in the unique manner shown by this illustration, namely the building of a sewer into one of the retaining walls of the railroad company's open-cut construction.

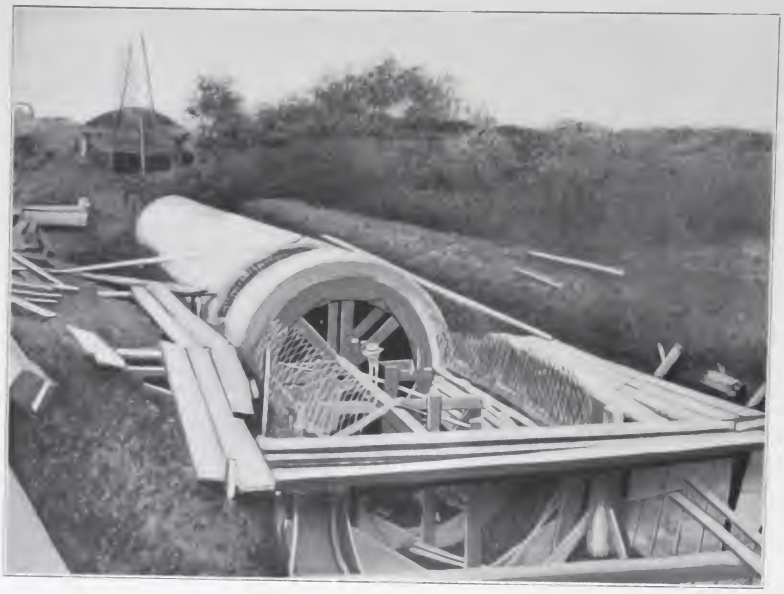


Figure 89

In Figure 86 is shown a cross-section through a marsh where its size was the largest indicated on page 46, and as will be seen in the illustration the concrete at the crown was only 8″. In Figure 89 is shown an illustration of the manner in which this was constructed. This section through the marsh extends above the natural surface of the ground and has so far had no covering of earth. Notwithstanding it has been subjected to heavy poundings of ice resulting from the breaking up of the ice of the Brandywine River, no damage has occurred to it.

In the large section of the sewer indicated a single sheet of 6″ No. 6 Expanded Metal was placed around as indicated, two inches from the inner surface, its position being carefully maintained by the men in construction. The economy of construction as well as the very desirable results have entirely satisfied the authorities under whose supervision this work was carried on.

In connection with the construction of sewers in general, we desire to invite attention to the possibilities of Expanded Metal as a medium of facilitating the construction and minimizing the cost of special features pertinent to sewage systems. To illustrate, there has recently been erected at Newton, Mass., a small, reinforced concrete sewage pumping station, fully described in the "Engineering News" of June 11, 1904. The station complete, including the machinery, cost $6,700; it was erected to avoid the construction of 3,600 feet of trunk sewer at an estimated cost of $45,000, which would have been too great a burden upon the property owners of the thinly populated district benefited by the system. The capacity of the pumping plant is sufficient to provide for the natural increase in population for many years to come, and should it eventually be necessary to replace the pumping plant by the trunk sewer, the saving will have been $500 per annum for this indefinite period of years. The side walls of the station are only eight inches thick and are of concrete reinforced with Expanded Metal and rods, and the floor system is reinforced with Expanded Metal. It is an excellent illustration of the small things that are money savers and the principle is applicable to many other similar features of sewage systems.

In Figure 90 is shown another use of Expanded Metal by Chief Engineer Assarson, of Brooklyn, in the construction of a roof over a sewer outlet. At this point also it was necessary to widen out and lower the line of the roof covering. This was done by the use of shallow beams laid at different levels, the whole being encased in concrete reinforced with Expanded Metal between the beams.

In other work similar to the above, Expanded Metal was largely used, viz., in the Atlantic Avenue Improvement in Brooklyn Borough, where the Long Island Railroad tracks were lowered, necessitating changes in manholes and sewers.

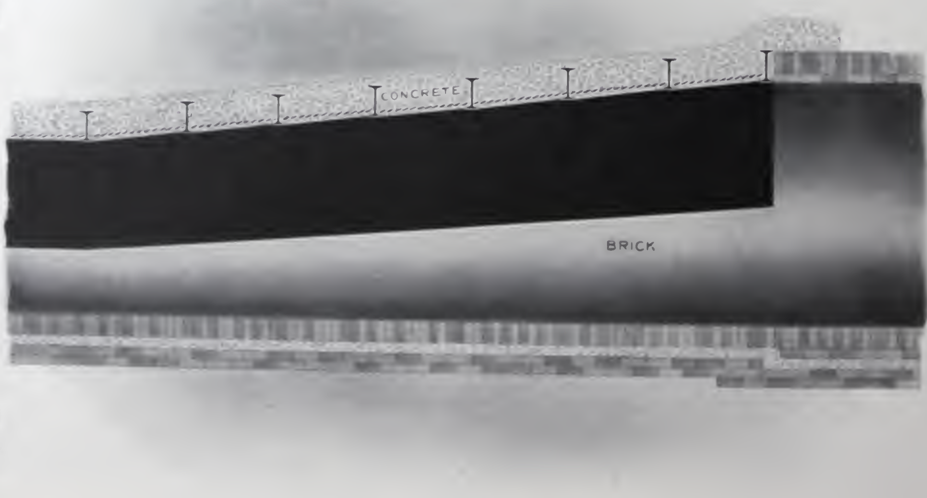


Figure 90

Figure 91 represents a very heavy reinforced water culvert, constructed a few years ago by one of the railroad companies of the West. In this there was a necessity for minimum thickness of concrete, and hence the use of two layers of Expanded Metal, the crown of this arch being so constructed as to carry railroad traffic without injury to the culvert.

Scores of other instances, with illustrations, might be furnished showing the use of Expanded Metal in the construction of concrete sewers under varying conditions, in all parts of the United States.

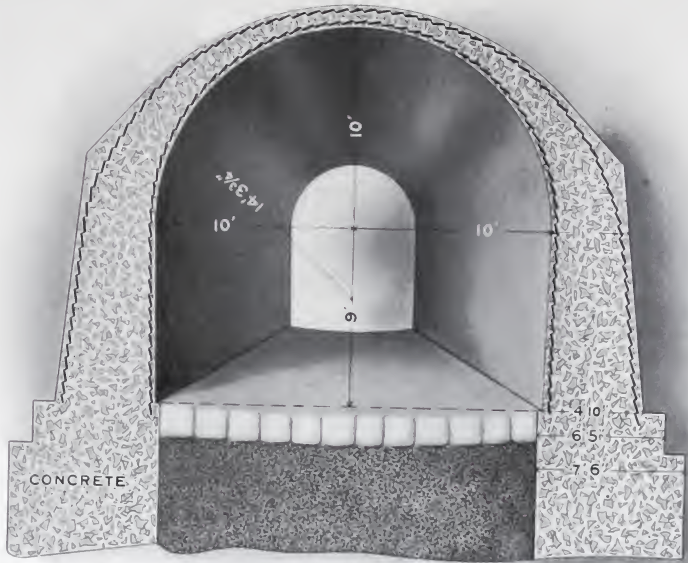


Figure 91

WATER-PROOFING CONCRETE

FOR waterproofing concrete surfaces that are subjected to slight or intermittent heads of water the "Silvester Process" has been used with success on some of the fortification works constructed by the government engineers. The method of mixing and applying was as follows: Thoroughly dissolve $\frac{3}{4}$ pound of shaved Castile soap in 1 gallon of water, also dissolve $\frac{1}{2}$ pound of powdered alum in 4 gallons of water. The walls should be dry and the soap wash applied first, at a boiling heat, being laid on with a flat brush and not allowed to froth. After the soap wash has been on about twenty-four hours and is thoroughly dry, the alum wash is applied in the same manner, being at a temperature of about 65°. This also should be allowed to dry for twenty-four hours before a second coat is put on. In a few cases one coat each of the two mixtures have been sufficient, generally two or three coats of each are necessary to make the concrete impervious to water. The application of the process gives the concrete a uniform color and generally improves the appearance.

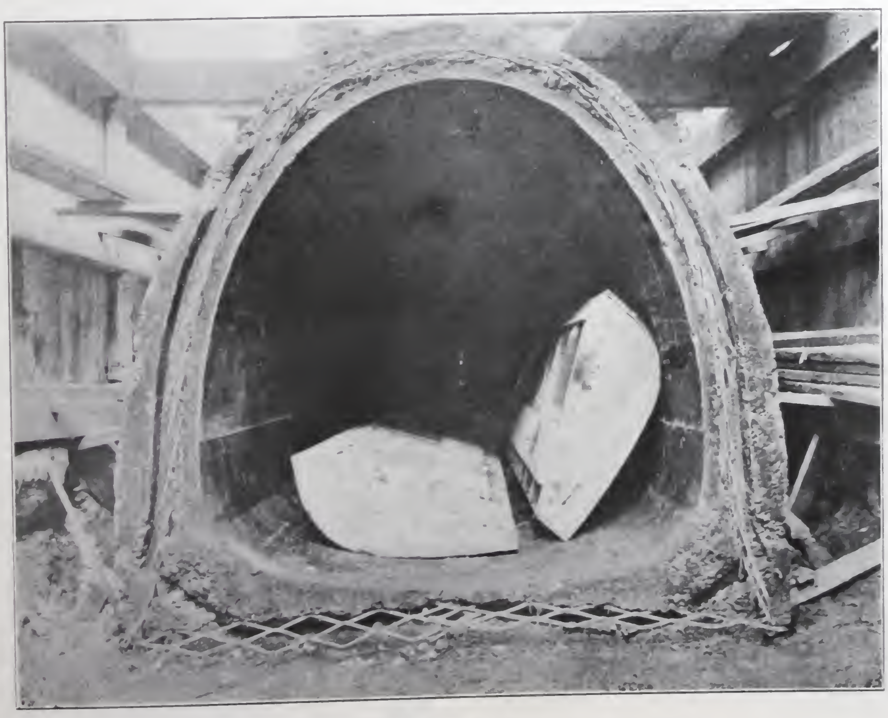


Figure 92

A WATER CONDUIT

IN Figure 92 is shown an illustration of the use of our material in a water-carrying conduit, built similar to one heretofore shown. This water conduit is a part of the Philadelphia water supply system and connects what is known as the Torresdale Filter plant with the pumping station. This section is 10′ in diameter and is 850′ in length. The water in this conduit is under 20′ head. In this case one layer of 6″ No. 4 extra heavy metal was used.

This work was constructed under the supervision of Mr. John W. Hill, Chief Engineer of the Bureau of Filtration, City of Philadelphia.

FILTER BEDS AT PHILADELPHIA

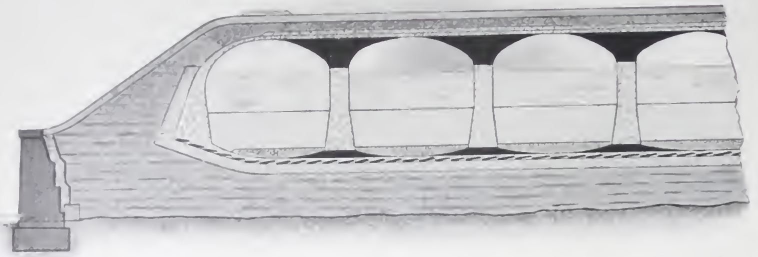


Figure 93

IN Figure 93 is shown a section of one of the filter beds which constitute a part of the Torresdale plant. In this instance, as in several others of these beds, Expanded Metal was used to reinforce concrete in forming the bottom of the filtration bed itself. This was necessary owing to the unreliable and uncertain ground in which the bed was to be placed. It was considered wise to make a monolith of the entire bottom of this bed, which had to carry not only the weight of the water, but had to support the columns carrying the roof.

In the construction of these filtration beds, water conduit, and other parts and connections of the water filtration system for the City of Philadelphia, more than one million square feet of Expanded Metal was used, furnished by Messrs. Merritt & Co., of that city.

SEWAGE TANK

THE accompanying illustration, Figure 94, is a cross-section of a sewage tank erected at Hanover, Pa., from designs made by the City Wastes Disposal Company, of New York City, C. Everett Hill, Chief Engineer. The tank is 72′ long and 35′ wide, and the roof is supported by ten brick piers 17″ by 17″, spaced at 12′ centers. The concrete is 6″ thick, reinforced with 3″ No. 10 Expanded Metal covering the whole area. Additional strips of the same metal 2′ wide run from side to side, and from end to end of the tank across each line of piers, bedded near the surface at each point of bearing, and sagging between, nearly to the bottom of the slab.

Figure 94

This scheme of construction for the purpose in this case proved to be entirely satisfactory, and has been used since by the same company in other work throughout the country.

Figure 95

CONCRETE TANKS

QUITE a variety has been accomplished in the building of reinforced concrete tanks, these having been built in various forms for different uses. The illustration herewith, shown in Figure 95, is made from a photograph taken in the plant of the Oxford Paper Company, at Rumford Falls, Maine. These tanks, thirty in number, average 20′ in height and 14′ in diameter. In their construction both economy and durability were accomplished. They were made at a less price than had previously been paid for wood tanks for the same purpose. The walls of these tanks were only 6″ thick, and were reinforced with double layers of Expanded Metal. They have proved satisfactory in every way to the owners as well as to the designer of the plant, Mr. James H. Wallace, Civil Engineer, of New York City.

COAL POCKETS

COAL pockets varying in size and style of construction have been built in various parts of the country for several of the most important industries. There are shown on this page two quite different in type. First, Figure 96 represents one of the coal pockets at Lowell, Mass., built for the Merrimac Manufacturing Company. These were built under the personal supervision of John W. Pead, general manager of the company. They were designed and constructed by the Eastern Expanded Metal Company, of Boston, whose work was done under the supervision of J. R. Worcester, of the same city. This coal-bin or pocket is not at all like the modern coal-bin. It is simply a rectangular box, coal being dumped into it from cars on an elevated track. It is then taken out at appropriate openings in the bottom.

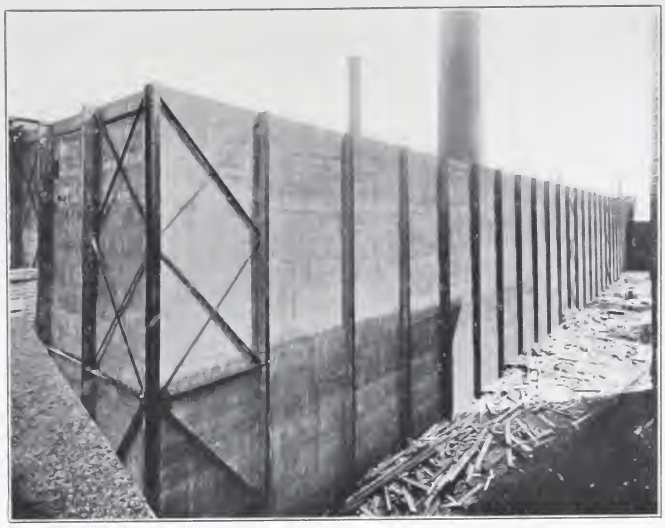


Figure 96

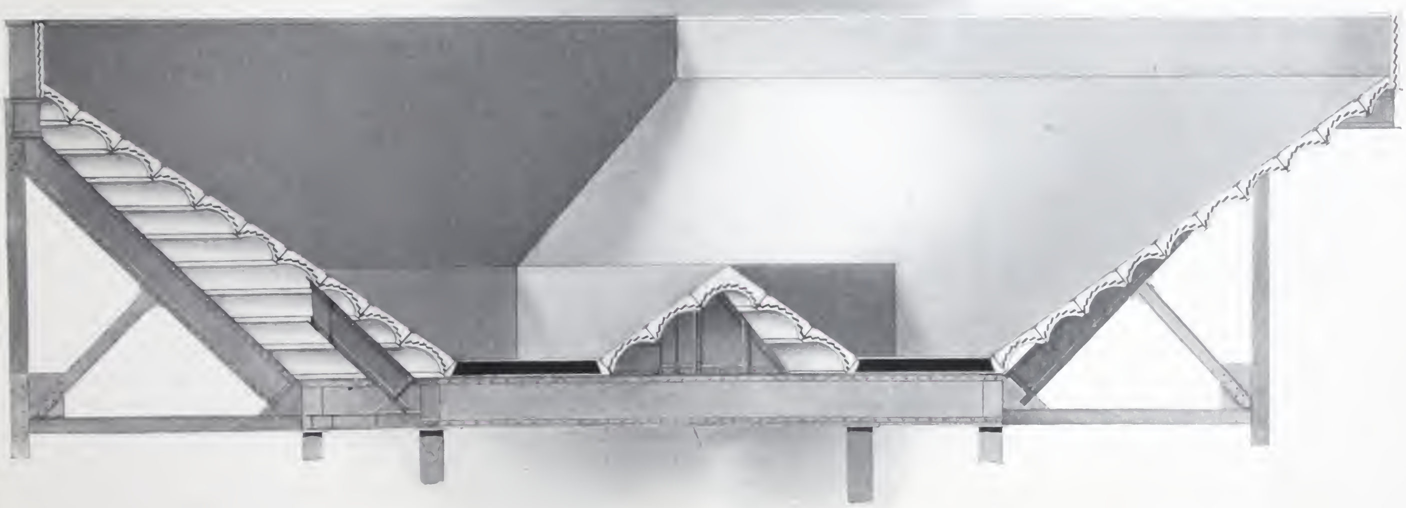


Figure 97

RAPID TRANSIT SUBWAY COAL POCKETS

IN Figure 97 is shown a diagonal section of one of the large coal pockets erected in the power house of the Rapid Transit Subway Company of New York City. An illustration of the power house is shown on page 40. There are seven of these coal pockets, similar in design and having a total capacity of 15,000 tons. They are located near the top of the building, 60′ above the boilers, and the latter are supplied directly from the coal pockets by a system of chutes. As may be seen from the accompanying illustration, the construction consists of a series of segmental arches of concrete reinforced with Expanded Metal and supported by I beams at regular intervals. Cinder concrete was used throughout, except that the interior or wearing surface consists of a granolithic finish about one inch thick. The coal pockets of the new power station of the General Electric Company, at Schenectady, N. Y., having a capacity of about 2,200 tons each, are constructed in a similar manner, except that the concrete is a continuous flat slab reinforced with Expanded Metal, and rests on the I beams. The coal is deposited in the coal pockets by a continuous conveyor, which also removes the ashes from the boilers, thus forming a complete and compact plant.

BRIDGES

In bridge construction Expanded Metal has been adopted in all parts of the country, and is now being used largely in all types of highway bridges. We show in connection herewith several illustrations indicating various methods for its use. In Figure 98 is illustrated a use for the material which has been adopted by the engineers of the State of New York for all small highway bridges, or what might be termed culvert bridges. In that State road improvement has advanced very rapidly and for the hundreds of small culverts or bridges, the standard type of construction consists of concrete or stone bearing walls across which is built in place the concrete slab reinforced with heavy Expanded Metal. In the illustration in question is shown an end elevation, as well as a section.

Figure 98

Figure 99

In Figure 99 is shown a highway bridge erected in Allegheny County, near Pittsburgh, under the supervision of T. W. Paterson, engineer of county roads. This bridge is built on a skew of 38 degrees, the rise of the arch is 4′ 1″, and the span of the bridge is 20′. It was one of the first bridges constructed of Expanded Metal and concrete in this country.

In Figure 100 is an illustration of the use of Expanded Metal for the reinforcement of bridge piers and retaining walls. The location of this bridge is at Sea Girt, N. J., and the bridge was built in 1899 by the Berlin Iron Bridge Company. The bridge proper consisted of steel girders with a wooden floor, but the bearings and wing walls were all reinforced concrete. This was deemed desirable at the time because of the fact that the bridge was located close to the sea and a heavy tide made the use of wooden wing walls impracticable.

Mr. W. W. Colpitts, Assistant Chief Engineer of the Kansas City, Mexico & Orient Railway, in an extensive article on the subject of reinforced concrete for railroad structures, says regarding abutments: "The saving effected by the use of steel concrete over plain concrete or masonry in abutments is very great, sometimes exceeding 40 per cent, and there seems little doubt but that their greater permanency and lessened cost of construction and maintenance will be a large factor in causing their more general adoption in the near future, particularly on lines which contemplate replacing pile trestles and other temporary works with permanent structures." The engineers of the K. C., M. & O. Ry. have thoroughly investigated the subject of reinforced structures and propose to erect a large number of them in the near future, covering a wide range of the application of reinforced concrete to railroad work in general.

Figure 100

Figure 101

In Figure 101 is shown an illustration of a concrete bridge, reinforced with Expanded Metal, erected at Santa Monica, Los Angeles County, in California. It is on the line of the Southern Pacific Railroad, and was constructed on the Expanded Metal Concrete system, designed by Mr. C. Leonardt.

The Western Expanded Metal and Fireproofing Company, who furnished the material for this work, have also secured its adoption in many other important enterprises along the Pacific Coast. It is being largely used in the construction of sugar houses, as well as in other like enterprises of note.

Figure 102

In Figure 102 is given a view from the under side of a highway bridge over the tracks of the Erie Railroad, in Newark, N. J. The structure was designed to carry two lines of electric railway cars, carriage ways, and sidewalk. The floor beams were 15″ I's spaced $6\frac{1}{2}'$ apart. The lower flanges of the roadway floor beams were wrapped with Expanded Metal lath and after the concrete arches had been put in, the under surface, including the floor beams, were plastered solidly with cement mortar. This was the first type of this style of bridge, built under the supervision of Mason R. Strong, bridge engineer for that company, since which time (1899) nearly every bridge along the line of the road has been built on the same system. Besides, this type of construction was adopted by the State Engineer of the Railway Commission of New York, and has been used on other roads as well.

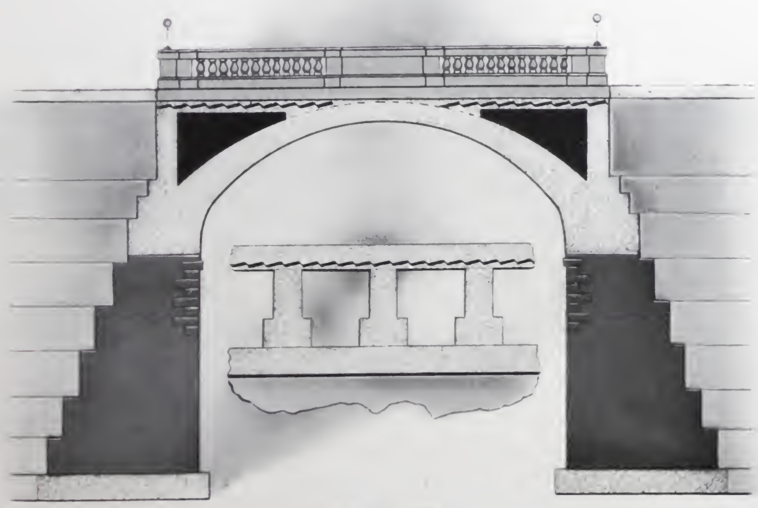


Figure 103

In Figure 103 is shown an illustration of the use of Expanded Metal for the reinforcement of concrete in a bridge now in the course of construction in the City of New York, being an extension of the famous Riverside Drive. The new section extends along the eastern shore of the Hudson River, and this bridge has to carry a driveway across an intervening street forty feet in width. The details show the manner of eliminating a large volume of concrete by the insertion of Expanded Metal. Designs for this work were made by F. Stuart Williamson, Consulting Engineer of the Department of Public Works, New York City.

DOCK WALL

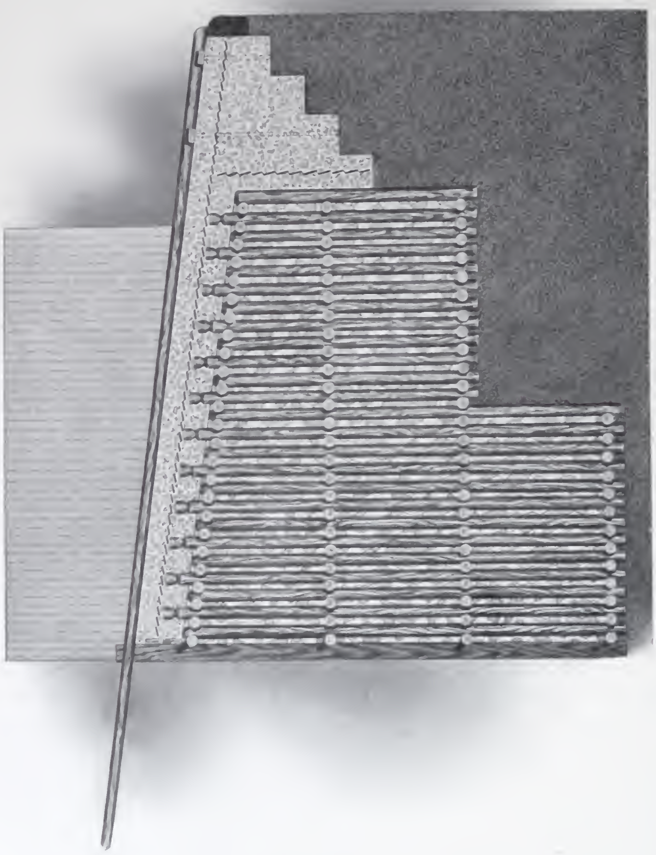


Figure 104

THE accompanying illustration, Figure 104, represents the use of Expanded Metal in the construction of a concrete retaining wall in Boston. The work was done by the Fitchburg Railroad Company, on plans approved by the United States Government, at the Charlestown Navy Yard.

The heaviest sheets of Expanded Metal made were used in this instance, the purpose being to prevent breaking of the concrete mass by the contact of heavy vessels against it. The scheme was very successful, and has been adopted in other Navy Yards in the country.

Similar methods have been used in the construction of retaining walls, wing walls, face walls and abutments by a great many of the leading railroad engineers, and the universal verdict is that a most satisfactory wall is obtained at a greatly reduced cost as compared with plain concrete or masonry walls. A very economical wall may be built by introducing buttresses at proper intervals and connecting them with a comparatively thin face wall of reinforced concrete, thus following a practice in vogue among French engineers.

Expanded Metal is suitable for all of the above-mentioned purposes; it also provides a better distribution of metal, and is more readily applied than any other form of reinforcement.

IN DOCK CONSTRUCTION

THE accompanying illustration, Figure 105, represents the use of Expanded Metal as adopted by Howard C. Holmes, Chief Engineer of the Dock Department, San Francisco. In this instance he has used Expanded Metal in the encasement of piles, which are driven two or more in a cluster, as well as for the erection of the floor of the dock proper. As will be seen in the accompanying illustration the steel work of the entire structure is encased in concrete. This same type of construction was used in the erection of the new docks built at San Juan, Porto Rico.

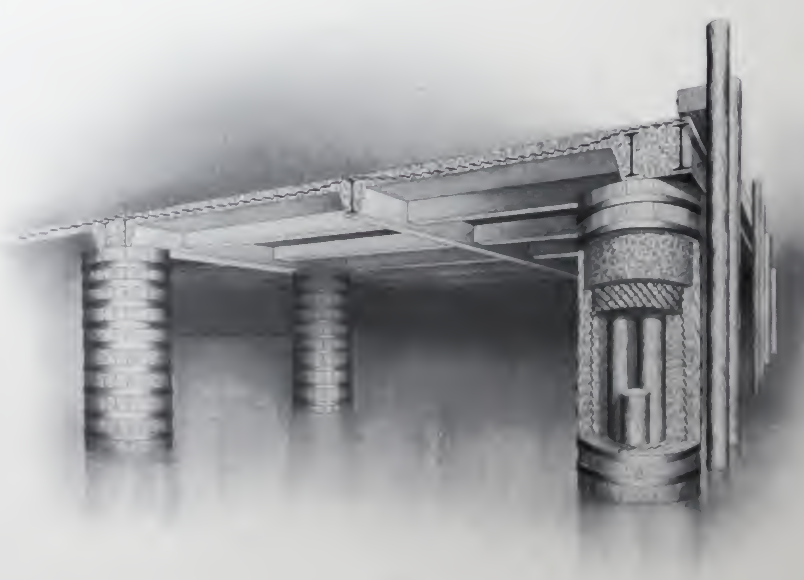


Figure 105

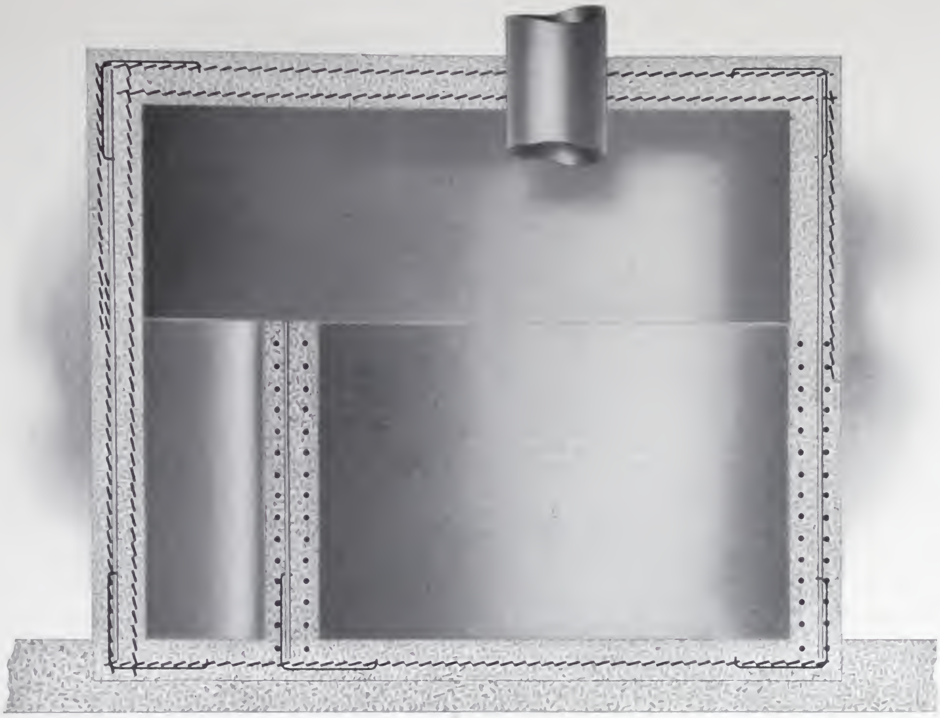


Figure 106

POWER HOUSE HOT WELLS

IN Figure 106 is shown an illustration of one of the twenty "hot wells" recently constructed in the immense power house of the Rapid Transit Subway Construction Company, New York City. These wells are a part of the enormous system in this power house, and, as in all other parts of the work, the best of everything was used. These wells are operated under heavy pressure at times, and hence the necessity for the best of reinforcement and the use of Expanded Metal.

Figure 107

DRY DOCK

IN Figure 107 is shown an illustration of work built by Mr. Holmes, in San Francisco. This shows the new dry docks erected at Hunter's Point, California. In the picture is shown the steamer "Siberia." Expanded Metal was used throughout the side walls and the bottom of the dock.

COAL SHAFT LININGS

A WORK of unusual importance has been accomplished by the engineers of the D., L. & W. Railroad in the anthracite coal fields which they control in Pennsylvania, namely, the lining of coal shafts. In this peculiar part of their important work, wood has been the only material in use since the opening of the mines, but it was ascertained later that concrete reinforced with Expanded Metal could be used for the purpose with economy, as well as guaranteeing perfect safety and permanency. In many of the mines quicksand and other unstable materials have to be contended with, so that a rocklike crib formed by these materials proved very effective.

A LIGHT HOUSE

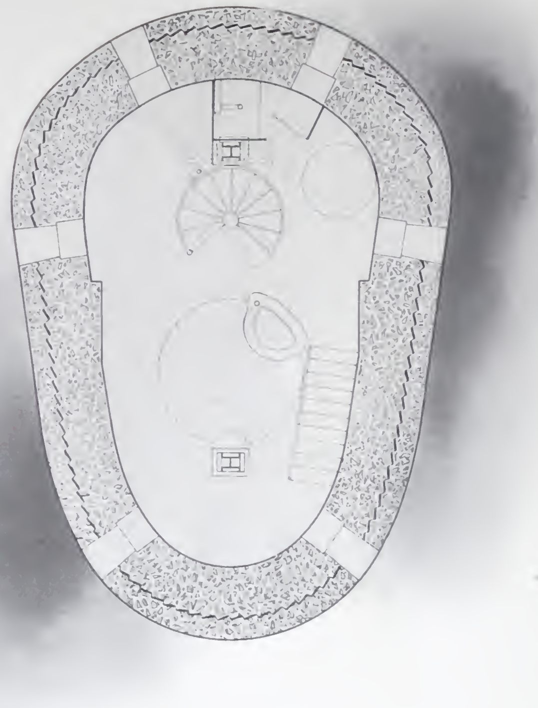


Figure 108

THE Mile Rock Lighthouse and Fog Signal Station, at the entrance to San Francisco harbor, is of steel and concrete. It is 90′ in height above mean tide-water. In the accompanying illustrations, Figures 108 and 109, are shown a cross-section through the store room, and a vertical cross-section. In this construction, which was carried out by the United States Government, the concrete was laid in a permanent steel mould formed of three-foot courses of steel plates, $\frac{3}{8}''$ thick and about 8′ long. Each course of plates was assembled as the concrete was laid, and is anchored to the concrete by two courses of crooked horizontal bolts, 12″ long, 3′ apart. The inner ends of these bolts project through a continuous sheet of Expanded Metal parallel to the plates and 12″ inside of it. The result of this combination is certainly what might be called a most durable and permanent construction.

The plans and specifications were prepared and the construction supervised by Mr. Thomas H. Handbury, Lieut.-Col. Corps of Engineers, United States Army.

CONCRETE FACING

IN response to frequent inquiries in regard to finished concrete surfaces, we quote below a few of the methods recently adopted on various works throughout the United States. On the fortification work at Newport, R. I., the forming for all exposed vertical faces is made of planed, tongued and grooved boards against which wet concrete, which is used throughout, is placed directly. As each layer of concrete is deposited, an ordinary garden fork is thrust down the inside face of the forming, so as to work the stone back, leaving a thin film of liquid mortar against the boards. There must be no openings through which the mortar may escape; with this precaution a smooth, hard and uniform surface is obtained, which is very satisfactory for that style of work, while the cost is nominal. Prof. Baker refers to a practice employed by the Wabash Railroad of washing concrete structures with a thin mortar made of cement and plaster-of-paris, which produces a marble-like finish.

In the "Engineering News" of February 4, 1904, Mr. H. H. Quimby, member American Society of Civil Engineers, describes at length the method used on the city bridges of Philadelphia. Briefly, the forms are removed while the concrete is "green" and the cement is washed off either with a hose or scrubbing brush, thus exposing the aggregate. The nature and color of the finished surface is dependent upon the aggregate used, therefore by a proper selection of the latter the general effect is under the control of the designer.

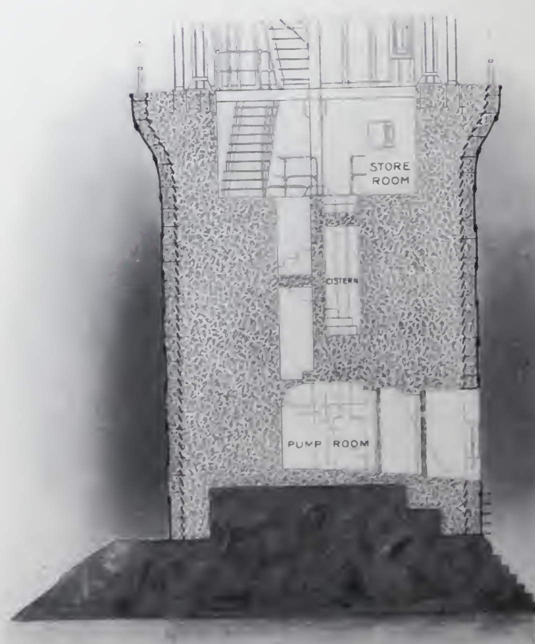


Figure 109

STAIRWAYS AT WORLD'S FAIR

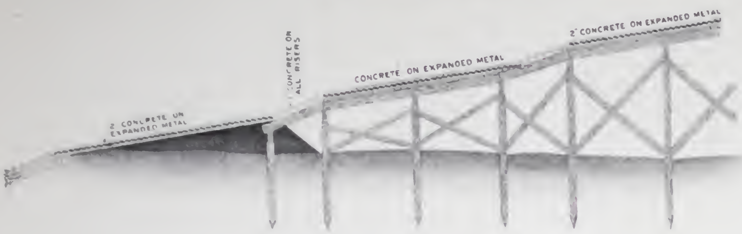


Figure 110

IN Figure 110 is shown on a very small scale the use of Expanded Metal as applied to the construction of the approaches to the Fine Arts Gallery, World's Fair, St. Louis. As will be seen, there is a series of short stairways connected by inclines of a low gradient instead of continuous steps. These inclines are slabs of Expanded Metal and concrete, built in position, carried on wooden piling and framework.

CONCRETE COLUMNS

THE reinforced column illustrated in Figure 112 possesses two interesting features. First, it is doubly reinforced; vertically, with rods, and laterally, with hooping made of Expanded Metal. Concrete when subjected to excessive compression without lateral support usually fails by oblique shearing. The hooping holds the concrete in place, preventing a separation of the particles and compelling each to perform its full share of the work by acting in unison, thus materially increasing the ultimate resistance of the whole. Columns have been built in this manner which sustain from 50 to 100 per cent. greater compressive loads than similar unreinforced columns, and are more economical than either steel or cast iron.

In the second place, the Expanded Metal hooping is wrapped with metal lathing, so that the cylinders thus formed may be placed in position, filled with concrete and a cement finish put on in practically one operation, without the use of moulds or forms of any kind. In short, it is a fireproofed column possessing the elements of economy and strength in a greater degree than any other form. Expanded Metal cylinders of any desired diameter, and wrapped with metal lath, may be made at the factory and shipped complete ready to place in position and fill with concrete. There are 221 of these columns now being erected for manufacturing purposes in a building in Brooklyn, N. Y.

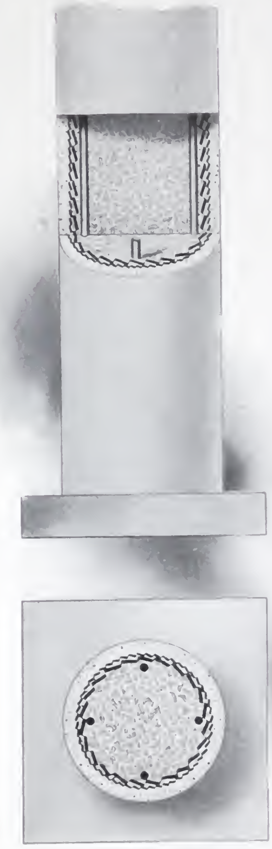


Figure 112

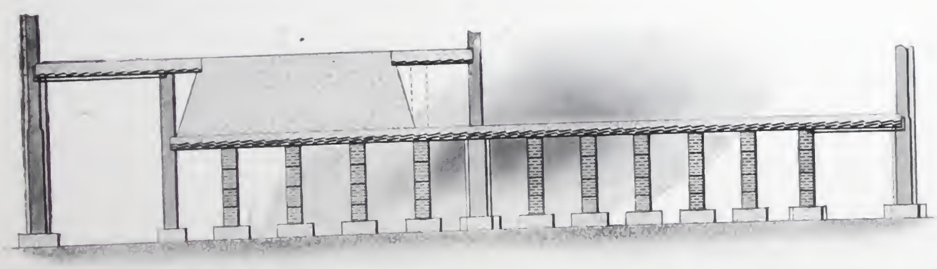


Figure 111

POWER HOUSE FLOORS

IN Figure 111 is an illustration of the use of Expanded Metal adopted several years ago by the well-known engineering firm of Sanderson & Porter, in the construction of the Queens Borough Electric Light and Power Company's plant, at Far Rockaway, N. Y. The following extract is taken from an article in the "Engineering News":

"The ground here offered a very poor base for foundations, and it was necessary to excavate to a depth of 10′ or more to hardpan. Upon this concrete bases were laid 4′ wide, 18″ in depth, and running the entire length of the building. These bases were spaced 6′ to 7′, center to center. A sectional plan and elevation of the foundation and floors is given in the illustration. Upon these strips of concrete brick piers 20″ square were built, spaced about 6′ apart, and rising to within 8″ of the level of the boiler-house floor. A false floor was then built, flush with the tops of the piers, and over the whole was spread a 2″ layer of concrete. While still soft this was covered with a layer of Expanded Metal, and then by another layer of concrete. Upon this was placed a second layer of Expanded Metal, and then the addition of 4″ more of concrete completed the floor.

Figure 113

DOCK BUILDING IN NEW YORK

FIGURE 113 is from a photograph recently taken of new pier No. 60, North River, New York. This pier is 1,000 feet in length and 100 feet in width, and is one of many being constructed by the Dock Department of New York City for the constantly increasing foreign traffic and the demand from Transatlantic Lines for larger facilities.

In this instance, the same as in the adjoining pier, No. 61, the pier proper is built on piles with heavy timber frame, over which is laid a slab of concrete 6″ thick, reinforced with Expanded Metal, the purpose being to unite the entire hundred thousand feet of area in one monolithic slab.

The work was designed by the Dock Department, of which John R. Bensel is Chief Engineer.

PIERS

THE scheme adopted in the reconstruction of the Penrose Ferry bridge, across the Schuylkill River, at Philadelphia, furnishes a typical example of the special application of Expanded Metal to one of the many details constantly met with in the design of bridge piers. In remodeling the bridge it was found necessary to increase the dimensions of the piers, which in turn necessitated driving additional piles. Through fear that unequal settlement would result and crack the concrete which serves as a capping for the piles and footing for the pier proper, a reinforcement of 6″ No. 4 Expanded Metal was introduced into the concrete to provide for an equal distribution of pressure. The metal was laid in the concrete just over the top of the piles and about 5,000 square feet were used in the various piers. The work has been completed several years and is giving entire satisfaction.

REINFORCED CONDUIT AT NEWARK, N. J.

IN view of a doubt still existing in the minds of some engineers as to the ability of reinforced concrete sewers or conduits to successfully withstand internal pressure due to a head of water, the following description and accompanying cut of the Newark, N. J., conduits are given. The data was obtained through the courtesy of Mr. Morris R. Sherrerd, Engineer of Water Department, Newark, N. J., and detailed information is given in the report of the

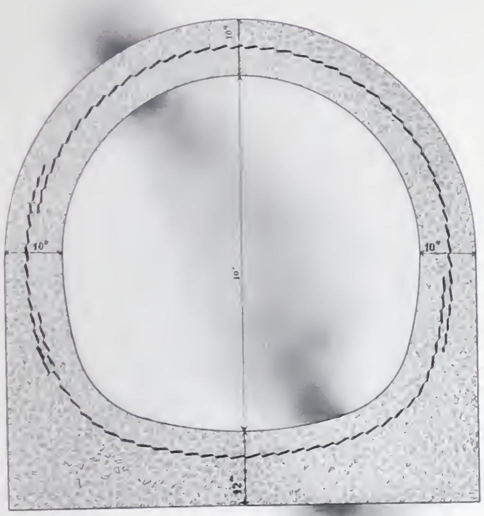


Figure 114

Tenth Annual Convention of the American Society of Municipal Improvement in a paper written by Mr. Sherrerd.

There has recently been completed in Newark 4,000 feet of single and 1,500 feet of double 60-inch conduits built of concrete in the proportions of 1:2:5 reinforced with 3″ No. 10 Expanded Metal. At times the conduits are subjected to pressure resulting from a head of 45 feet. Before finally adopting the reinforced concrete form of conduit, sections were built and subjected to pressure. Referring to these experimental sections Mr. Sherrerd states: "A section of single and a section of double were built. The double conduit was built practically as a monolith, but the construction of the single conduit was interrupted, and a horizontal joint was made in the section. Both of these sections were tested under hydraulic pressure, wooden heads being bolted to the ends so that the sections could be filled with water. The single conduit gave way at the horizontal joint under a pressure supposed to be about 15 pounds, the pressure being accidentally applied before the time set. The double conduit was tested up to 35 pounds, which was as much pressure as could be obtained with the heads used. The concrete showed no signs whatever of weakness, and this section has been incorporated as part of the permanent work." The engineer also states that after a little experimenting the conduits were built in monolithic masses as easily as they could have been built in any other way, and that an expansion joint was made at the end of each day's work, which was approximately 30 linear feet. These joints opened perhaps 1-32 of an inch without serious leakage. A careful comparison of costs was made in which it was found that the reinforced concrete conduits cost $5.95 per foot for a single line and $11.75 per foot for a double line of 60-inch conduit as against $14.00 per foot for single line and $28.00 per foot for double line of cast-iron pipe of the same size, exclusive of excavation in both cases, and that a total saving of $40,000 was effected by the use of reinforced concrete.

FOUNDATIONS

IN the development of footings and foundations in general, where from the nature of the soil it is necessary to increase the bearing area and at the same time economize space, the practice has advanced from the old style of wooden crib work through numerous stages to plain concrete and footings of steel rails or beams imbedded in concrete. These two forms, while possessing infinite advantages over the preceding methods, are nevertheless susceptible of further improvement. In footings of steel beams incased in concrete the latter is merely a binding and protecting material, in many cases reinforced concrete is preferable and decidedly more economical than the steel beam form, as in the former the metal may be placed to work to the greatest advantage in resisting tensional stresses and the concrete is utilized for resisting compressive stresses. In every instance the introduction of Expanded Metal in connection with the beams may be shown to be a decided benefit toward securing both an equalization of the load and an economical construction. In plain concrete footings the projection of the footing courses are comparatively small, necessitating a series of courses to obtain the desired spread. This in turn requires a greater depth

of concrete, more excavation and in many cases valuable cellar space is occupied by the footing courses. All of these disadvantages may be eliminated by the introduction of Expanded Metal reinforcement into the concrete. Generally speaking, a reinforced concrete footing designed for given conditions of loading will be approximately one-fourth the depth of a plain concrete footing designed under the same conditions and will cost from 15 to 25 per cent. less. In addition there is saving of space and increased safety, the unreliable tensile strength of plain concrete having been replaced by a reliable tension member of metal.

In foundations where piles are driven and capped with concrete, inserting Expanded Metal materially reduces the thickness of concrete and insures an equal distribution of pressure.

Figure 115

In many instances where continuous and deep foundations would otherwise be necessary, clusters of piles may be driven or piers erected, at suitable intervals, and the latter spanned by comparatively shallow reinforced concrete girders, upon which the superstructure may be erected direct, resulting in a substantial saving of time, labor and material.

EXPANDED METAL SPECIALTIES

IN previous pages there have been shown many illustrations descriptive of the uses to which the larger proportion of the product of five Expanded Metal factories in this country is put. In the erection of buildings, this material is used in almost every portion of the structural parts thereof. It is also being largely used in the equipment and furnishing of many classes of buildings. It has been used in many as guards for windows, for enclosures of elevators and stairways, and in other instances as railings. It is used in many large factories also to enclose a portion of each floor, which constitutes a tool room or stock room for valuable materials.

Figure 116

We show illustration herewith of a very large use for the material in the construction of lockers for the use of employees. For this purpose Expanded Metal has been in use about five years. These lockers have rapidly displaced the old style wooden lockers and are also taking the place of wire lockers. The old-style wooden locker, consisting of a solidly enclosed box, is rarely built where owners have anything like a correct idea of up-to-date methods. The wooden affair soon becomes foul and breeds vermin, making them unfit receptacles for even factory use. Wire lockers, although they afford ventilation, are not secure, as the wires can be pressed aside and the contents of the locker removed. This is not true of the Expanded Metal locker because it is impossible to open the joints between the various meshes without entire destruction of a panel, and this cannot be done without the use of some very heavy tools. These lockers are open on all sides to admit the great disinfectants, light and air, and as the entire affair is made of steel there is very little opportunity for lodgment or absorption of germs of any sort.

In Figure 115 is given an illustration of a set of lockers installed in the Union Station of the Pennsylvania Railroad, at Pittsburgh, Pa.

Figure 116 represents a slightly different practice in the use of Expanded Metal for office and factory

Figure 117

use. This is an illustration of a file case which was built for the Cambria Steel Company, of Johnstown, Pa. Valuable papers, when kept in dark and damp places, soon are destroyed from lack of ventilation, and cases of this sort overcome these disadvantages as well as make possible the locking up of file cases which may contain documents of more or less value.

Figure 117 illustrates how a large railroad company furnishes the best toilet facilities and locker room for its employees. This represents a view in the shops of the Union Pacific Railroad, at Omaha. As indicated in the illustration, the room devoted to this purpose is all light and airy. Messrs. Merritt & Co., 1024 Ridge Avenue, Philadelphia, have been making a specialty of these lockers and their present output averages over 3,000 per month. They also are prepared to make Expanded Metal into any desirable form in the way of case-enclosure work.

In Figure 118 is shown an illustration of a tree box made from 2″ mesh of Expanded Metal, which is 6½′ in height and 12″ in diameter. It makes a very strong and secure guard for the protection of trees against the biting horse, as well as the lad with a new knife.

These instances, illustrating the varied uses of Expanded Metal mesh, might be multiplied *ad lib.* The desirableness of a sheet of mesh which, without rim, frame or border, enables its use will suggest many opportunities for practice to any mechanical mind. The sheets in any mesh can be furnished in any size desired, and are easily bent into any form desired for especial use.

Figure 118

EXPANDED METAL IN IMPORTANT NEW YORK ENTERPRISES

IT will not be amiss, on this, one of the last pages of this catalogue, to recapitulate and put into a single chapter the varied uses to which Expanded Metal has been put in some of the most important enterprises in and around New York. Just at this period, and while reinforced concrete may be said to be in its infancy, it is interesting to know that in practically all of the world-famous engineering enterprises Expanded Metal has figured in a large degree. It might be mentioned that during the last six years in the building of new and in the rebuilding of old buildings in the Brooklyn Navy Yard, Expanded Metal has been introduced in almost a score of buildings.

In the erection of the New York Edison Company's famous Waterside Station, Thirty-eighth street and East River, 200,000 feet of Expanded Metal was used in the floors and roofs.

In the Rapid Transit Subway construction this material has been used in practically every department. In the manholes of the main subway more than 100,000 feet has been used. It was practically used exclusively in the construction of the power house referred to elsewhere in this catalogue, also in the repair shops, in the sub-stations, as well as in the passenger stations.

In the Manhattan, or Elevated Railway system, many hundreds of thousands of feet of our material has been used in the erection of the special features, including hot-air ducts, hot wells, floors in subway stations, repair shops on elevated tracks, etc.

In the North River tunnel, being built for street car use, it has been used in the construction of manholes and other similar work.

In the vast improvements being made by the New York Central Railroad in their terminal system large quantities are being used.

Likewise in the tunnels and other improvements to cost $40,000,000, by the Pennsylvania Railroad, Expanded Metal is an important factor in the reinforcement of concrete.

It is also being used exclusively by the Subway companies (in the construction of manhole covers), whose conduits carry all of the telephone and telegraph wires in the city.

The New York Telephone Company make use of it in large quantities in their construction department.

Expanded Metal has not only been used by all of these large concerns in the reinforcement of concrete, but in many other ways, as indicated elsewhere.

EXPANDED METAL ABROAD

THE manufacture of Expanded Metal is rapidly extending to the various countries of the Continent, and unfortunately for indifferent linguists, new names are being manufactured as well. For instance, we have "Métal Déployé" in France, "Streckmetall" in Germany, "Traliccio Di Lamiera Stirata" in Italy, "Tragnetzbleck" in Russia and "Metal Desplegado" in Spain. Large quantities of Expanded Metal are being used in India also, but it is noted with a feeling of gratitude that as yet no one has had the temerity to attempt the native nomenclature.

Our friends of the "other side" have not taken up the fabric without careful investigation and having subjected it to rigorous tests. In London the distinguished firm of Fowler & Baker made, during 1896, exhaustive tests of concrete slabs reinforced with Expanded Metal. Details of these tests will gladly be furnished upon application and the following quotation from their report gives a general idea of the results: "This summary shows that the use of Expanded Metal in the case of 3 ft. 6 in. span increases the strength of a flat concrete slab from six to eight times the strength for carrying an uniform load that it would have if made without Expanded Metal; and in the case of the 6 ft. 6 in. span the strength is increased to ten and eleven times."

In the reconstruction of the Elswick Works of Armstrong-Whitworth Company, after their partial destruction by fire, Expanded Metal was used throughout. It was not selected, however, until searching preliminary tests had fully demonstrated its worth. These tests were made before a select committee of the Northern Architectural Association (England) and have been summed up as follows by Mr. A. C. Davis, F.C.S.: "The New Expanded Metal Company have reason to be particularly proud of this achievement, as not only in the satisfaction of so eminent an engineering firm, who, unlike most principals, were personally able to appreciate the splendid character of the work, but in having given satisfaction to Mr. Rich, who ranks among those who are absolutely at the head of the profession in the North of England." The Expanded Metal floors in these shops carry lathes and other machinery used in turning out the heaviest kind of ordnance manufactured by the Armstrong-Whitworth Company.

The most conspicuous of the many examples of the use of Expanded Metal in Scotland is the Granton Gas Works erected by the Edinburgh and Leith Corporation Gas Commissioners. The entire floor system is constructed of concrete reinforced with Expanded Metal, including the foundations for the retort settings.

In the Paris Exposition more than 1,000,000 square yards of Expanded Metal were used in the erection of buildings and bridges, the most notable being the Mining and Metallurgical building, the Royal Hungarian pavilion, the Imperial Russian pavilion and the Pont Alexander III across the Seine.

A similar list may be given of buildings in which Expanded Metal was used at the Glasgow Exhibition of 1901, the Cork Exhibition of 1902 and the Earl's Court Exhibitions.

The New Central Bridewell Gaol, erected in Dublin several years ago, is constructed entirely of concrete, the floors, roof and stairs being reinforced with Expanded Metal. The general effect, while naturally severe, is handsome, conveying at the same time an impression of great strength. Another handsome building in Dublin in which Expanded Metal floors, partitions and ceilings were used throughout, is the Royal Victoria Eye and Ear Hospital, of which Messrs. Carroll and Batchelor are the architects.

The Pont Ilyssos, Piræus, Greece, is an attractive and substantial looking bridge 90 feet long and 26 feet wide, constructed in three equal spans. This bridge is entirely of reinforced concrete, Expanded Metal being used for reinforcing the decking and sidewalks and round rods for reinforcing the beams. The hand rails are of Expanded Metal, producing a decidedly finished appearance to the structure as a whole. Upon completion the bridge was subjected to a severe test by the government engineers.

Metal lathing and plaster construction in some one of the various forms is quite popular in India. Its use in all classes of buildings is reported, from the ornate pavilions of the Delhi Durbar to a large number of laborers' dwellings along the line of the Bengal and Nagpur Railway. Many officers' quarters in Bombay constructed of steel frames, Expanded Metal and plaster present a pleasing appearance and are in keeping with the surroundings. This method of construction is particularly adapted for the buildings of an army post, by reason of the rapidity of erection, the added protection against fire where the facilities of extinguishing a conflagration are comparatively crude, the cost of repairs being comparatively insignificant and the possibility of producing quarters that will harmonize with the fortifications as well as the natural features of the post.

We may also add that by the use of a hollow wall such as is illustrated on page 23, an air space of any desired width may be obtained, which prevents dampness and condensation, adding greatly to the comfort of a house at all seasons and permitting all piping and wiring to be concealed, if so desired, without any dangerous results.

CONCRETE MIXTURES

CONCRETE is composed of a matrix, which may be either a Portland or natural cement mortar, and an aggregate of either slag, shells, broken brick, cinders, gravel or broken stone. Widely varying proportions are used for mixing concrete in general practice, and in many cases the quantities are gauged in so crude a manner as to result in a waste of material and indifferent concrete.

Mixtures.			Required for 1 cubic yard rammed concrete.											
			Stone, 1 in. and und., dust screened out			Stone, 2½ in. and und., dust screened out			Stone, 2½ in., with most small stone screened out			Gravel, ¾ in. and under		
Cement	Sand	Stone	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.	Cement, bbls.	Sand, cu. yds.	Stone, cu. yds.	Cement, bbls.	Sand, cu. yds.	Gravel, cu. yds.
1	1.0	2.0	2.57	0.39	0.78	2.63	0.40	0.80	2.72	0.41	0.83	2.30	0.35	0.74
1	1.0	2.5	2.29	0.35	0.70	2.34	0.36	0.89	2.41	0.37	0.92	2.10	0.32	0.80
1	1.0	3.0	2.06	0.31	0.94	2.10	0.32	0.96	2.16	0.33	0.98	1.89	0.29	0.86
1	1.0	3.5	1.84	0.28	0.98	1.88	0.29	1.00	1.88	0.29	1.05	1.71	0.26	0.91
1	1.5	2.5	2.05	0.47	0.78	2.09	0.48	0.80	2.16	0.49	0.82	1.83	0.42	0.73
1	1.5	3.0	1.85	0.42	0.84	1.90	0.43	0.87	1.96	0.45	0.89	1.71	0.39	0.78
1	1.5	3.5	1.72	0.39	0.91	1.74	0.40	0.93	1.79	0.41	0.96	1.57	0.36	0.83
1	1.5	4.0	1.57	0.36	0.96	1.61	0.37	0.98	1.64	0.38	1.00	1.46	0.33	0.88
1	1.5	4.5	1.43	0.33	0.98	1.46	0.33	1.00	1.51	0.35	1.06	1.34	0.31	0.91
1	2.0	3.0	1.70	0.52	0.77	1.73	0.53	0.79	1.78	0.54	0.81	1.54	0.47	0.73
1	2.0	3.5	1.57	0.48	0.83	1.61	0.49	0.85	1.66	0.50	0.88	1.44	0.44	0.77
1	2.0	4.0	1.46	0.44	0.89	1.48	0.45	0.90	1.53	0.47	0.93	1.34	0.41	0.81
1	2.0	4.5	1.36	0.42	0.93	1.38	0.42	0.95	1.43	0.43	0.98	1.26	0.38	0.86
1	2.0	5.0	1.27	0.39	0.97	1.29	0.39	0.98	1.33	0.39	1.03	1.17	0.36	0.89
1	2.5	3.5	1.45	0.55	0.77	1.48	0.56	0.79	1.51	0.58	0.81	1.32	0.50	0.70
1	2.5	4.0	1.35	0.52	0.82	1.38	0.53	0.84	1.42	0.54	0.87	1.24	0.47	0.75
1	2.5	4.5	1.27	0.48	0.87	1.29	0.49	0.88	1.33	0.51	0.91	1.16	0.44	0.80
1	2.5	5.0	1.19	0.46	0.91	1.21	0.46	0.92	1.26	0.48	0.96	1.10	0.42	0.83
1	2.5	5.5	1.13	0.43	0.94	1.15	0.44	0.96	1.18	0.44	0.99	1.03	0.39	0.86
1	2.5	6.0	1.07	0.41	0.97	1.07	0.41	0.98	1.10	0.41	1.03	0.98	0.37	0.89
1	3.0	4.0	1.26	0.58	0.77	1.28	0.58	0.78	1.32	0.60	0.80	1.15	0.52	0.72
1	3.0	4.5	1.18	0.54	0.81	1.20	0.55	0.82	1.24	0.57	0.85	1.09	0.50	0.75
1	3.0	5.0	1.11	0.51	0.85	1.14	0.52	0.87	1.17	0.54	0.89	1.03	0.47	0.78
1	3.0	5.5	1.06	0.48	0.89	1.07	0.49	0.90	1.11	0.51	0.93	0.97	0.44	0.81
1	3.0	6.0	1.01	0.46	0.92	1.02	0.47	0.93	1.06	0.48	0.97	0.92	0.42	0.84
1	3.0	6.5	0.96	0.44	0.95	0.98	0.44	0.96	1.00	0.45	1.01	0.88	0.40	0.87
1	3.0	7.0	0.91	0.42	0.97	0.92	0.42	0.98	0.94	0.42	1.05	0.84	0.38	0.89
1	3.5	5.0	1.05	0.56	0.80	1.07	0.57	0.82	1.11	0.59	0.85	0.96	0.50	0.76
1	3.5	5.5	1.00	0.53	0.84	1.02	0.54	0.85	1.06	0.56	0.89	0.92	0.48	0.78
1	3.5	6.0	0.95	0.50	0.87	0.97	0.51	0.89	1.00	0.53	0.92	0.88	0.46	0.80
1	3.5	6.5	0.92	0.49	0.91	0.93	0.49	0.92	0.96	0.51	0.95	0.83	0.44	0.82
1	3.5	7.0	0.87	0.47	0.93	0.89	0.47	0.95	0.91	0.49	0.98	0.80	0.43	0.85
1	3.5	7.5	0.84	0.45	0.96	0.86	0.45	0.98	0.86	0.47	1.01	0.76	0.41	0.87
1	3.5	8.0	0.80	0.42	0.97	0.82	0.43	1.01	0.81	0.45	1.04	0.73	0.39	0.89
1	4.0	6.0	0.90	0.55	0.82	0.92	0.56	0.84	0.95	0.58	0.87	0.83	0.51	0.77
1	4.0	6.5	0.87	0.53	0.85	0.88	0.53	0.87	0.91	0.55	0.90	0.80	0.49	0.79
1	4.0	7.0	0.83	0.51	0.89	0.84	0.51	0.90	0.87	0.53	0.93	0.77	0.47	0.81
1	4.0	7.5	0.80	0.49	0.91	0.81	0.50	0.93	0.84	0.51	0.96	0.73	0.44	0.83
1	4.0	8.0	0.77	0.47	0.93	0.78	0.48	0.95	0.81	0.49	0.98	0.71	0.43	0.86
1	4.0	8.5	0.74	0.45	0.95	0.76	0.46	0.98	0.78	0.47	1.01	0.68	0.42	0.88
1	4.0	9.0	0.71	0.43	0.97	0.73	0.44	1.01	0.75	0.45	1.04	0.65	0.40	0.89
1	5.0	9.0	0.66	0.50	0.90	0.67	0.52	0.93	0.70	0.53	0.96	0.61	0.46	0.83
1	5.0	10.0	0.62	0.47	0.95	0.63	0.48	0.96	0.65	0.50	1.00	0.57	0.43	0.87

The proportion of matrix should slightly exceed the voids in the aggregate, so that each particle of the latter may be entirely covered with mortar. It is, therefore, evident that the proportion of voids in the aggregate, to be used in each particular case, should be ascertained in order to secure the best results. This is simply done by filling a vessel of known capacity, level full, with the loose aggregate, having previously thoroughly wet the latter. Then pour in as much water as the vessel will contain, and divide the volume of the water poured in by the volume of the vessel, the quotient will represent the proportion of voids. The mixture may then be proportioned accordingly, which will not only produce a better grade of concrete, but frequently affect a material saving over the common method of arbitrarily adopting one of the usual proportions, regardless of the nature of the ingredients. In general, for both sand and stone, the particles should vary in size, within certain limits, so that the smaller sizes shall partly fill the voids of the larger, thus forming a stronger concrete with a less amount of cement. No hard and fast rules can be laid down for mixing concrete, either by hand or by machinery; the main object is to secure a thorough mixture of the ingredients at a reasonable cost. Machine mixing is undoubtedly superior, and is usually adopted whenever it is practical to do so; the mixing machine, however, does not relieve one of the responsibility of exercising the proper precautions dictated by experience and common sense, one of which is constant and competent supervision of the mixing.

There has been more or less controversy as to the superiority of wet or dry mixtures. The consensus of opinion of a majority of engineers seems to favor a surplus of water, and recent experiments and experience indicate quite clearly that wet mixtures offer better protection to imbedded metals and is consequently preferable for reinforced concrete.

Another distinct advantage of a wet mixture is that it may be placed at less cost than a dry mixture.

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